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The Strength of Hollow Columns.

SINCE Euler propounded his celebrated theory, many rules have been evolved for calculating the strength of columns, and all of these that enable the user to make approximately accurate predictions are really based upon the purely mathematical investigation to which we refer. It is true that the forms of the various equations are such that the source of their origin is not very apparent, and as Euler's formula is only applicable to long columns where failure takes place as the result of elastic bending, it must be modified for use in connection with columns of practical proportions. In what follows, the round-ended column alone is considered, and for this Euler's theory is thus expressed:— $P = \frac{\pi^2 E I}{l^2}$

where E = the coefficient of elasticity of the material, I = the moment of inertia of the section, and l = the length of the column.

As, however, a very short column fails by direct crushing, its strength depends upon the value of $F_c A$, the first factor representing the ultimate compressive strength of the material and the second the area of the section. A connection between this expression and Euler's formula may be made by a combination of the two. Thus:

$$P = \frac{F_c A}{1 + F_c A \, (l^2 \div \pi^2 E I)}$$

In this we have an equation which gives $P = F_c A$, when l is very small, and $P = \frac{\pi^2 E I}{l^2}$ when l is very great, while for intermediate values of l, the results agree roughly with those ascertained by experiments. To effect a still closer agreement, the formula has been modified by the introduction of purely empirical constants. Gordon, acting upon a suggestion by Tredgold, adopted the following equation:—

$$P = \frac{F A}{1 + c \, (l \div d)^2}$$

Where F is a constant depending on the strength of the material, c a constant depending on the material and the section of the column, and d = least diameter or breadth of the section.

This is clearly unsatisfactory, because the least diameter, or least breadth, cannot help to distinguish between the strength of columns having different forms of cross section.

Then Rankine modified Gordon's formula by substituting the least radius of gyration for the least diameter, thus making the rule suitable for columns of any section. As so modified, the equation stands

$$P = \frac{F A}{+ \; c \, (l \div r)^2}$$

Here F and c are still constants, but their values depend only on the properties of the material, and the values of F and c selected by Rankine were

such as seemed to represent most closely the results of actual experiments.

In more recent times, many engineers have proposed different coefficients for the purpose of making the results given by the formula more applicable to practical columns, in which ideal conditions are never realised and where variations of strength occur owing to defective workmanship, lack of homogeneity of the material, initial curvature, and other causes.

With regard to hollow columns of wrought iron or steel, it has been known for a long time by the experiments of Fairbairn and Clark that their ultimate resistance depends very much upon the thickness of the plate, but until recently no attempt has been made to establish the most economical ratio between the thickness of metal and the radius of gyration of the section. This deficiency is made good to a certain extent by the experiments of Professor W. E. Lilly, who has communicated some of the results obtained in a paper read a week or two ago before the Institution of Mechanical Engineers. For the purposes of the tests mild steel tubes were employed, the diameters ranging from $\frac{3}{8}$ in. to 1 in., and the thickness from 16 S.W.G. to 22 S.W.G. As might be expected, some differences occurred owing to variations in the quality of the material, but as more than eight hundred experiments were carried out, the figures now made public can be accepted as fairly representative. The most important results are stated in seven diagrams, and from curves in these corresponding with average values Professor Lilly has calculated six curves which are plotted on another diagram, showing the influence of thickness in determining the load producing failure. To make comparison more easy, the cross section of the columns considered in these curves is kept constant, only the diameter and thickness being varied. The relation between length and the radius of gyration ($l \div r$) is indicated on the base line of the diagram, and breaking loads are shown vertically. Among the phenomena observed during the course of the investigation, the following are worthy of special note:—(1) That for all columns there was a certain value of the ratio $l \div r$, beyond which failure sensibly resulted from elastic bending, the load causing failure varying inversely as the square of the length. This constitutes one more proof of the general accuracy of Euler's theory. (2) That as the value of the ratio $r \div t$ (radius of gyration ÷ thickness) increased, the value of $l \div r$ increased for the load causing failure by elastic bending. Examination of the values obtained makes clear the fact that the load causing failure was less when the diameter was varied and the thickness constant, and greater when the thickness was varied and the mean diameter constant. This indicates that strength depends in some way upon the ratio $r \div t$. For the purpose of determining values corresponding with the constant (F) used in Rankine's formula, various values of $r \div t$ and the breaking load were plotted by Professor Lilly, and the following rule was obtained:

$$f = \frac{F_c}{1 + k\,(r \div t)^2}$$

where $f = F \div A$, k is a constant for mild steel $= \frac{1}{800}$, and t = thickness of metal.

The values of f given by this equation appear to conform closely to those required. Hence the Rankine formula as used by Professor Lilly becomes

$$p = \frac{P}{A} = \frac{F_c}{\left\{1 + k\left(\frac{r}{t}\right)^2\right\}\left\{1 + c\left(\frac{l}{r}\right)^2\right\}}$$

This modified form of Rankine's rule takes into consideration both primary and secondary flexure, and gives results that are more generally applicable than the formula as ordinarily written. But it should be noticed that as the strength of long columns is governed by the coefficient of elasticity, and not by the resistance of the material, as in the case of columns too short to fail by flexure, it necessarily gives results that are too low for very short columns and too high for very long columns. Consequently, as

Professor Lilly remarks, it would be more logical to employ a rule based more directly upon Euler's formula. For the present, however, he is of opinion that it is better to employ the Rankine formula until further experimental data have been obtained.

The investigation up to the present has only extended to round-ended columns, and a good deal more work remains to be done before the investigation can be regarded as complete. We are glad to know that the experiments will be resumed in the near future, and it will be extremely interesting to have a further communication from Professor Lilly on this important subject.

One valuable result is the formulation of a simple rule for practical use indicating economic values of $l \div r$, and of $r \div t$ for columns of hollow circular cross section. A modification of the same rule is also proposed for columns of other cross sections, but of course the essential constant for this has still to be determined by experiment.

The German Commercial Treaties.

THE British press has paid but little attention to the new treaties of commerce which Germany has just made with several of her neighbours, yet it is possible that the effect of these treaties may be felt not only in the countries which are parties to them, but also in Great Britain, and especially in her great manufacturing industries. This indifference to the action of a great commercial rival is all the more surprising when we note that the speech in which Count von Bülow introduced the treaties to the Reichstag on the 1st of February is full of matter of the highest interest to ourselves at a time when our politicians are keenly engaged in a controversy concerning the advisability or otherwise of introducing changes in our fiscal legislation by adopting a policy of "retaliation" towards other nations in commercial matters. With the purely political aspect of the German treaties, however, we are not here directly concerned; but their possible effect on our trade, especially on the iron, engineering, and allied industries, seems to deserve our earnest consideration.

In 1879, Germany, guided by Prince Bismarck, adopted a policy of protection for her industries, with the result that in a few years' time her commerce developed in a very remarkable manner. This led the neighbouring States, which had suffered by the German protection, to impose high tariffs upon German goods, thereby closing to some extent the foreign markets which had previously received most of the German surplus manufactures. To remedy this evil, Germany, in the early nineties, set to work to arrange with her neighbours commercial treaties which should remain in force for a long period of years, thus ensuring for a definite time a general international exchange of commodities. At that time the main desire of Germany was to foster her manufacturing industries, and therefore, in coming to terms with other States, which had to receive a *quid pro quo*, she made concessions at the expense of the agricultural industry. The time has now come for these treaties to be renewed, unless they are to be allowed to lapse altogether; but they cannot be renewed on the same terms. Germany herself, or at least the German Parliament, where the agrarian party is strong, desires now to restore her agricultural industry to the same favourable position which it occupied before the policy of commercial treaties was adopted, but she can only secure an increased tariff on agricultural produce by allowing the other parties to the treaties to impose an increased tariff on German manufactures, and in the new treaties which have just been made, this has been the basis of negotiation.

The countries with which fresh treaties of commerce have been concluded are Italy, Belgium, Russia, Rumania, Switzerland, Servia and Austria-Hun-

gary; and from the date when the treaties come into force—that is, February 15th, 1906—Germany will not find as ready a market for her manufactures in any of those countries as she has had there during the past twelve years. Naturally, this is not altogether a pleasing prospect for the German industries, and it is not surprising to find that there is considerable dissatisfaction in some quarters, but there seems little doubt that the terms will be accepted by the Reichstag as representing the best bargain possible under the circumstances. We may therefore consider briefly some of the probable consequences.

The general result that is anticipated is very concisely expressed in a communication to *The Times* (Feb. 6th, 1905) from its Berlin financial correspondent, whom we may quote. He says that the general impression produced upon the Berlin Bourse by the publication of the seven new treaties is not unfavourable, notwithstanding the fact that serious injury to the German export trade may be anticipated from the increased duties which these States have imposed upon the importation of German industrial products, among which the German iron trade will be the greatest sufferer. Particularly Russia, Austria-Hungary, and Rumania have seen fit to raise the duties upon German iron and iron goods. The chemical industry, the paper industry, the electrical industry, and also the textile industry will be far more severely handicapped in the markets of the world under the terms of the new treaties.

Now, it cannot be expected that an active nation like Germany will be content to see its foreign trade diminish, and if she finds old markets less ready to take her goods than before, she will naturally set about to find new markets or to make still greater efforts in old markets which are not regulated by these fiscal treaties. What is more natural, therefore, or more probable than than she should turn her attention to the British market, where there are no tariffs in her way? We know that in the electrical industry, for example, German competition has had serious effects in recent years upon British manufacturers, who have had to submit to a process of cutting of prices while they cannot retaliate in German markets. It will be noticed that the electrical industry is one of the German industries which will now be severely handicapped in other European countries, and while the home trade of these countries will benefit by this fact, it seems at least probable that part of Germany's loss may be handed over to us. The same holds good of the chemical industry and of the iron industry, and therefore of the engineering trades generally. In all these trades we may expect within a year's time to find increased competition from Germany. Count von Bülow, in telling the Reichstag that the new treaties were intended to come into force on February 15th, 1906, added that German commerce and industry would thus have a whole year to make arrangements for facing the new situation. We would therefore warn our manufacturers to keep a watchful eye during the next twelve months upon their German rivals, and so be in a position to protect their own interests at home and also in foreign and colonial markets.

There are many points in Count von Bülow's speech which merit close attention, but as they are more of a political character, as showing the growth of a nation under a system of protection, we need not dwell upon them here. It is of interest, however, to notice that part of the speech in which Count von Bülow sketched the progressive change in the distribution of the population of the German Empire. In the year 1871, he pointed out, 64 per cent. of the population lived in rural districts; by the year 1895 the rural and the urban populations were about equal; while to-day the town population accounts for 54 per cent. of the total, only 46 per cent. remaining in the country. This change indicates rapid industrial development at the expense of agriculture,

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but the new increased tariffs on agricultural produce may tend to check somewhat the rate of change. Germany seems to consider that her industries are now established on a firm basis, and as she is a military nation, requiring not only a home food supply, but also a large yeoman class to fill the ranks of her army, she now seeks to encourage her agricultural industry as being to her of the highest importance.

The British Engineer in Competition with the World.

WITHIN the last year or so, eminent men in the engineering world, and many others who have no connection with the profession, have placed their views freely before the public upon the position and future prospects of British engineering industries. Highly gifted as these speakers and writers may be, their opinions cannot carry more weight than the thoroughly practical and outspoken remarks contained in the admirable presidential address delivered by Mr. A. P. Turner at the commencement of the present session of the Ipswich Engineering Society. Although it would be difficult, if not impossible, for anything intrinsically new to be said with regard to the great battle before the British engineer, Mr. Turner has expressed himself upon a well-worn topic in a manner that must commend itself to all thinking men, and particularly to those engaged in the commercial branches of engineering. Referring at the outset to the struggles of those early engineers whose monuments of usefulness are still with us, the speaker pointed out that the great engineer of to-day must be qualified to hold his own in a greater world than that in which his predecessors lived and worked. Hence, as he remarked, "the problem to be considered is the equipment of the present engineer, and the preparation of the coming one."

We have repeatedly argued that, while technical education is of supreme importance, it is not the one thing needed for the salvation of our industries. This conviction, we are glad to find, is shared by Mr. Turner, as it also is by manufacturers generally. Still, it is quite right to place education in the forefront, so long as we make sure that the proper kind of training is covered by the term. In the address to which we now direct attention, it is made clear that even if a man be educated until he becomes full of knowledge to overflowing, he will not necessarily be a successful engineer. We have heard much about the excellent collegiate institutions of various foreign countries, and have been told that the provision of similar establishments would go a very long way towards remedying the ills of which British manufacturers complain. But it must not be forgotten that, even when ability and the desire to study are present, a college can only do one half of what is necessary. The remainder must be looked for in the workshop. The nearest approach to this dual training is to be found in some of the American universities, among which we are proud to include the McGill University of Toronto, so justly eulogised by Sir William White in his recent address before the members of the Institution of Civil Engineers. Hence it comes about that the American graduate passes out from his college with a fair amount of workshop practice, sufficient in fact to enable him to become proficient after a comparatively short period in an engineering shop.

The detailed consideration given by Mr. Turner to the educational systems of America and the Continent deserve careful study, and we quite agree with him as to the advantages secured by the American system. It is true, as he says, "Not an institution in this country can offer similar instruction." Yet there is no need for alarm. Our educational institutions are increasing in number and improving in quality. Universities all over the country are catering more and more for engineering students: technical colleges and schools, mechanics' institutes, and polytechnics

continue to multiply, and, what is more important still, the great employers are showing strong practical interest in the educational movement. Systems such as those established by Mr. Yarrow, the Great Eastern Railway, and many others, afford training that is far superior to any that can be obtained elsewhere in the world.

A great proportion of the educational work promoted by employers is dedicated to the use of working men. This involves sacrifices and efforts of no mean order, and, to crown such efforts with success, co-operation is imperatively required. This aspect of the question is not overlooked by Mr. Turner, who asks in a pointed way: "Where does the reciprocating spirit come in?" After showing that no people in the history of the world have ever laboured under such favourable conditions as prevail in this country to-day, he asks whether we find in response to such benefits, anything like an equivalent increase in the output of the workers to pay even a slight percentage on the outlay incurred. The answer is clearly in the negative. Hard facts tell us that though shops may be equipped with the most up-to-date machinery, the output remains far less than in other countries where the workmen receive higher wages than our own. Limitation of output, which keeps down the pay of good men, is the quack remedy swallowed with blind faith by the mechanic of to-day. The compounders of this nostrum are the trade unions, whose reprehensible and laudable objects are discussed at some length by Mr. Turner. We need not follow his remarks on the present occasion, except to express agreement with him that in various directions these bodies are doing really useful work that has the entire sympathy and support of the employers. Nothing could be better for employers and employed than the union of both classes to provide superannuation and benefit funds to insure the means of existence for those faithful servants whose work is done, and for others who may be temporarily deprived of employment by sickness or slackness of trade. If such a trade union could be realised, then, to use the words of Mr. Turner, "restricted output, trade unlon threats, workmen and employers as opposing factions, incapable workmen being paid above their true worth, all this will be a past history, and the British engineer will be again pre-eminent, and successfully face the competition of the world."

The Germicidal Value of Copper.

A RECENT issue of the *Century Magazine* contains an interesting illustrated article on the experiments conducted by the Department of Agriculture at Washington in regard to the use of copper sulphate as a preventive of the growth of algæ and certain pathogenic organism in water supplies. It has been found that different algæ can be killed by the reagent when added to the water in minute quantities. A curious scale of resistivity apparently exists; for while certain varieties need 1 part in 2,000 for their destruction, others, such as the *Uroglena Americana* were killed by the addition of one part in ten millions. A case is cited in Virginia of some watercress beds which were so infested with spirogyra that the industry was severely handicapped. These growths were eradicated by the addition of copper sulphate in the proportion of one to fifty million parts of water; while an addition of one in four million parts was effective against the anabænas, a frequent source of odour in water supplies.

Prior, however, to the publication of the article in the *Century Magazine*, a paper was read by Dr. Rideal and Dr. Baines at the Glasgow Congress of the Sanitary Institute, in which the effect of copper sulphate, copper chloride, and copper foil on specific pathogenic organisms was described. The 1 per 1,000 copper sulphate solution was made by

crushing the crystals and dissolving in water. This solution was subsequently found to contain 1 part of copper in 3,825. At the end of one hour an admixture of distilled water containing bacillus coli with copper sulphate (a 1 in 5,000 copper in solution) was rendered sterile. The bacillus typhosus was killed within three hours. The 1 per 1,000 copper chloride solution—made by drying the crystals at 100 deg. C., and containing 1 part of copper in 2,600, and also mixed with distilled water in the proportion of 1 in 26,000—killed the coli in three hours, and the typhoid bacillus in one hour. For equal weights of the salts the chloride is more efficient; but as the actual amount of copper in the two solutions was in the ratio of 3,825 to 2,600, it would seem that the efficiency is roughly dependent on the absolute amount of ionic copper present. A further experiment was therefore made on water containing the coli bacillus. The strengths of the two salts requiring to kill the bacillus in three hours were found to be between 1 in 13,000 and 1 in 14,000 of copper chloride, corresponding in each case to a percentage of about 0.003 or metallic copper.

The experiments of Nageli, Galeotti, and others, have already shown that metallic copper produces an effect sufficient to render water toxic to many forms of algæ and bacteria. The Department of Agriculture has shown that an area of about 1 sq. cm. to each 100 cc. of water is sufficient for exterminating wroglena and some forms of spirogyra from a reservoir. Dr. Rideal and Dr. Baines, therefore, placed copper foil in sterilized flasks, adding water inoculated with various cultures. The results of these experiments showed the exposure of water which is open to contamination in clean copper vesesls for not less than 24 hours would render it safe for drinking purposes.

This curious effect produced by copper would probably be of value for military purposes, and soldiers' flasks and regimental water-carts should be made of copper, while the copper kettle should be restored to favour for domestic use. Dr. Rideal does not furnish any explanation of the toxic properties which he shows that copper possesses. Can these be due to an infinitesimal amount of the copper being dissolved in the water? Or does copper emit any rays, hitherto undetected, which have a bactericidal effect? The immersion of a frame (upon which is wound a few hundred yards of bare copper wire of small diameter) in a glass vessel containing distilled water, specially inoculated, and re-inoculated with micro-organisms, would,, in a few weeks, provide an answer to the first question, if weighed before and after use. If that were in the affirmative, the second question need scarcely be put.

British Engineers in America.

The address delivered recently before the Institution of Civil Engineers, by Sir William White, has received a two-fold character. As a permanent record in the proceedings it will possess historic value, for it describes the main incidents connected with the first official visit ever made by a representative body of the institution to the United States and Canada. Again, as delivered, at the recent meeting in free and unconventional style, it will be remembered by those who were numbered among the audience. As many of our readers are aware, the visit in question took place last year, when Sir William White was president of the institution, at the invitation of the American Society of Civil Engineers, but the programme was extended to include visits to Canada and Chicago, in response to wishes expressed by the Canadian Society of Civil Engineers and the Western Society, respectively. A considerable part of the address is occupied by references to the great engineering works of New York and district. Railways, tramways, tunnels, and bridges, tall buildings, waterworks, and drainage systems all receive adequate mention,

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but as the chief undertakings of the kind have been described over and over again in the technical press, the information now presented possesses no features of novelty. Similar criticism is applicable to the account given of the brief visit made to Chicago by the representatives of the institution.

In dealing with Canada, Sir William occupies himself less with purely descriptive matter, and states in unrestrained language the profound impression made upon him by the great waterways and canals of the Dominion, and by the enormous rescources of that great country in the way of water power. The active efforts being made by the Canadian Government for connection of the great lakes with the sea fully deserve the commendation bestowed upon them, and another most satisfactory development in recent times is the rapidly increasing utilisation of water power in the generation of electricity. But the most important point urged in the whole address is in a passage wherein it is made clear that for the complete development of the agricultural and mineral wealth of Canada, and for the extension of industrial operations throughout the land, engineering schemes on a most extensive scale will be absolutely necessary in the immediate future. Sir William White has grasped the situation with the hand of a master, and he speaks with no uncertain voice of the splendid opportunities afforded by the Dominion for British capital, commercial enterprise, and engineering skill.

Sawing Stone by Wire.

STONE sawing by wire is done successfully in France, according to a paper by Mr. E. Bourdon in the *Bulletin* of the Society for the Encouragement of National Industry. A complete plant comprises an endless wire passing round a series of pulleys, one of which is a driving-pulley. The necessary tension is obtained by a straining trolley working on an inclined plane, and between the driving shaft and this trolley is situated the saw frame, which carries the guide-pulleys for the wire saw. This wire, which is driven at a given speed, is caused to press lightly on the stone, and the cutting is done by sand mixed with water, which is conveyed into the saw-cut as the work proceeds. Though the mode of operation appears simple, it entails various difficulties in practical application. Three twisted steel wires are used, each wire having a diameter of 0·098 in. The strands must be twisted fairly tight and should make one turn in 1·18 in. The wire may be driven in the workshop at a speed of 23 ft. per second, but in quarries or adits the speed should not exceed 13 ft. per second. The force exerted by the wire to produce the cut must be uniform and must be capable of being readily varied; moreover, it must be proportionate to the length of the cut.

The Steel Car in the United States.

By GEO. L. FOWLER.

THE steel car, as it stands in the United States to-day, is an evolution from a wooden structure by the slow steps of elimination and substitution. The time is well within the memory of men now actively engaged in railroad work, when all parts of the body and trucks, that could possibly be so constructed, were of wood. Drawbars and their fastenings, wheels, axles, and journal boxes and wearing parts were metal—cast iron, for the most part—but everything else, including truck frames and bolsters, were of wood. In those days the capacity of the standard freight car was 10 tons or 20,000 lb., and the weight of the vehicle was the same. Then, along in the later seventies, came the increase in carrying capacity, calling for a corresponding strengthening of the cars. This was done by the gradual elimination of the wooden parts and the substitution of metal.

It was not, however, until 60,000 lb. had come to be the recognized standard carrying weight of freight cars that the construction of a steel car body was strongly advocated. By this time steel had driven wood entirely out of the field for the parts of the truck, and when speaking of the steel car the American has reference to the body only.

The great difficulty encountered in the construction of such a car was found to lie in the low cost of the high grade timber that was available for the construction of sills and framing, and which could be so worked up as to be of ample strength to carry the loads of 60,000 lb. that would be imposed. And here, in the price of wood, is to be found the real reason why European railways were so far in advance of those of the United States, in the matter of time, in the introduction of the steel body for cars intended for both passenger and freight service. But as the advantages of high capacity wagons for carrying coarse bulk freight, such as coal and ores, came to be appreciated there arose a growing demand for something to take more than the standard

STEEL HOPPER BOTTOM GONDOLA CAR.

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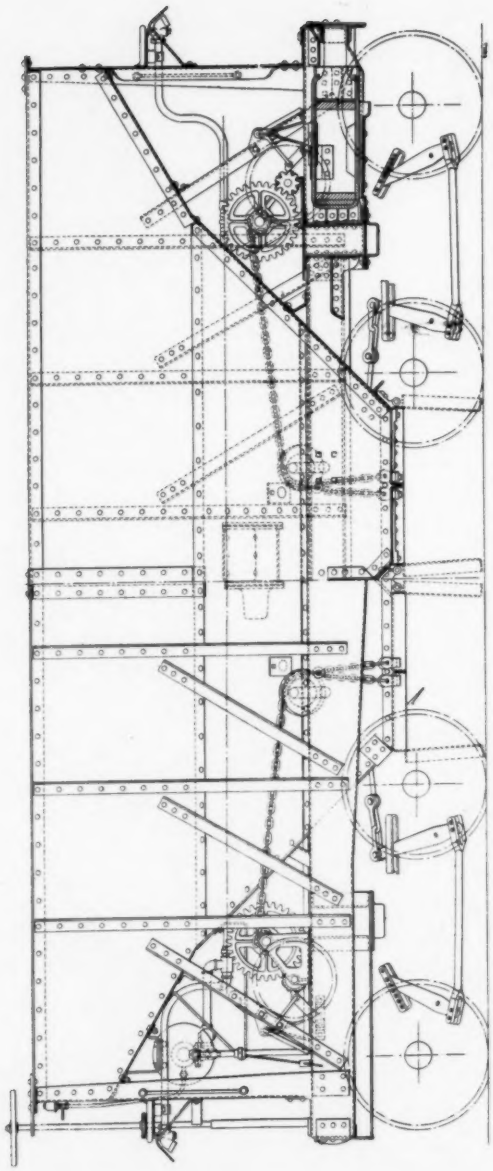


SIDE ELEVATION AND LONGITUDINAL SECTION OF PRESSED STEEL HOPPER BOTTOM ORE CAR OF 100,000 LBS. CAPACITY, BUILT BY THE PRESSED STEEL CAR CO., PITTSBURG, PA., U.S.

60,000 lb. For this, wood could be made to answer, but it was not satisfactory, and straightway we began to hear of designs for steel cars.

The goal at which the early designers aimed was to produce a wagon of a higher carrying capacity than the wooden wagon at the same price, so as to be able to offer an inducement to the purchaser to take the new construction. For this reason, special shapes were discarded and the standard rolled sections used. This involved some waste of material due to faulty distribution, which was further handicapped by an absolute ignorance on the part of all concerned as to the stresses to which a wagon body is subjected when in motion. The result of this ignorance, coupled with the necessity of saving material, was that the early steel cars were too light for the service for which they were intended, and soon gave out. This led to some unwarranted prejudice on the part of railroad officials against the steel wagon, though as stated in a report before the Master Car Builders' Association in 1896, it is "quite as unjust to condemn all iron or steel car construction on account of these failures as it would be to condemn the use of wood in car construction because some of the earlier builds of cars, and even some comparatively recent designs, are so poorly proportioned that they are constantly failing."

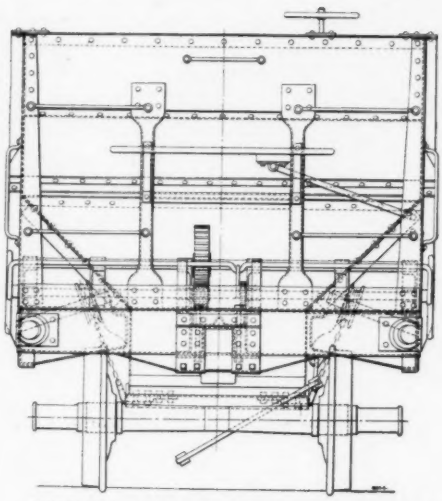
This prejudice, however, was not very deep-seated, for it was evident to all that the demands of the transporta-

tion department could only be met by the construction of high capacity cars, and this meant an extensive use of steel. The minds of the railroad community were also prepared for the acceptance of the new construction by the development of the steel truck and the gradual substitution of steel for many parts of the bodies that had already taken place. In fact, the steel car was being promoted, not only by builders, but by many master car builders who entered the field as designers and put out cars intended both for special and general work.

These early designers were handicapped by the necessity of practically competing in price with the wooden car, and also the overcoming the fears of the users.

All manner of evil prognostications were made as to the durability of the new construction. It was thought that rust would work such havoc with the material that the life of the structure would be abnormally short, while, in case of a wreck, it was a foregone conclusion that the parts would be so twisted and distorted that there would be no possibility of making repairs, and the car would be a total loss. How far these forebodings were substantiated we will see later.

The steel car was agitated for some time before it took on material form, and it is difficult to locate its first appearance exactly. Barring the construction of a large number of tubular iron cars that were built in the early eighties, and which were so weak in design that they served as an awful example for years, the first steel cars to attract widespread attention in the United States were some that were built by the Harvey Steel Car Co. in the latter part of 1892. This car was built strictly along the lines of the old wooden-frame wagon, the only change being found in the substitution of steel for certain of the wooden parts. The centre sills were of 12 in., and the side and intermediate sills of 6 in., I beams. The latter were trussed in the same manner as the wooden sills. The other steel parts consisted of the end sills which were 6 in.



END ELEVATION OF PRESSED STEEL HOPPER BOTTOM ORE CAR OF 100,000 LBS. CAPACITY.

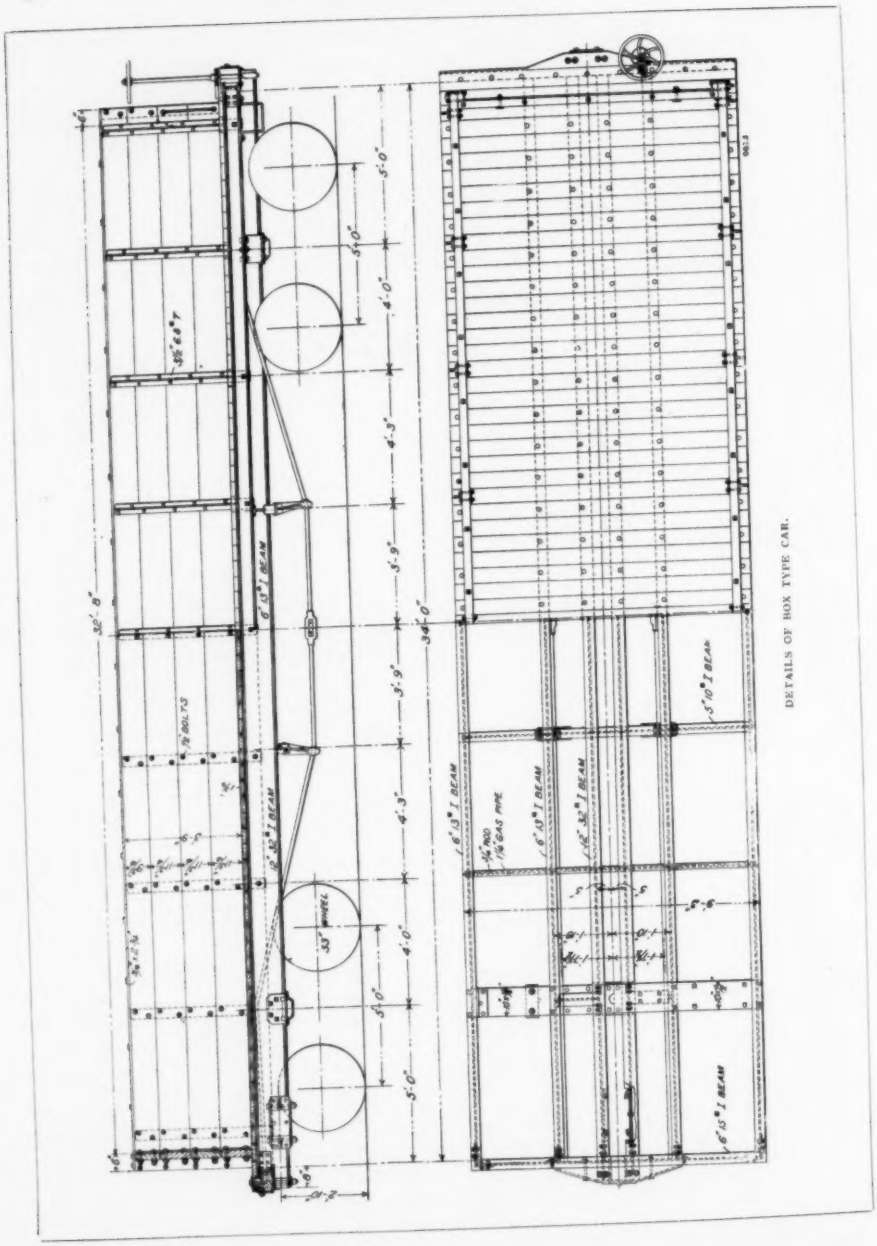
I beams, cross-tie-timbers, side stakes, and bolsters. The sides and floorings were of wood.

Meanwhile, other designers were at work, and during the next three years a number of designs were brought out and cars built.

The successful introduction of the pressed steel truck and the development of pressed steel frames in England was having its effect and influencing American designs to a marked extent. The result of this work was manifested by the rather notable exhibit of steel cars at the Master Car Builders' Convention held at Saratoga in 1896. The examples shown at that time were made up of shapes, and of pressed forms only. The capacities of the cars ranged from 60,000 to 80,000 lb.

Curious enough, in spite of the interest manifested by the railways and the large sums spent by the builders in designing and constructing steel cars, orders were not forthcoming, and what little building was done was on single and small lots for special work.

A number of cars had been made for some of the steel works in and about

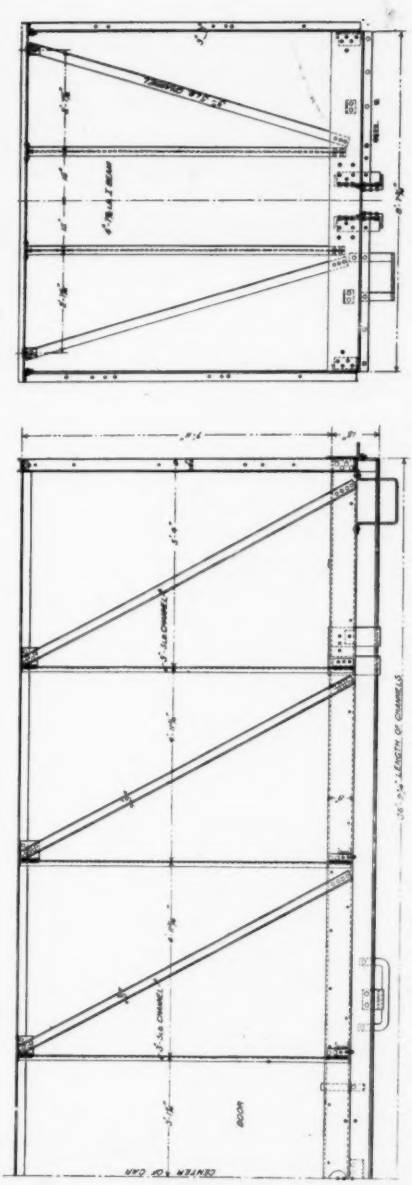


DETAILS OF BOX TYPE CAR.

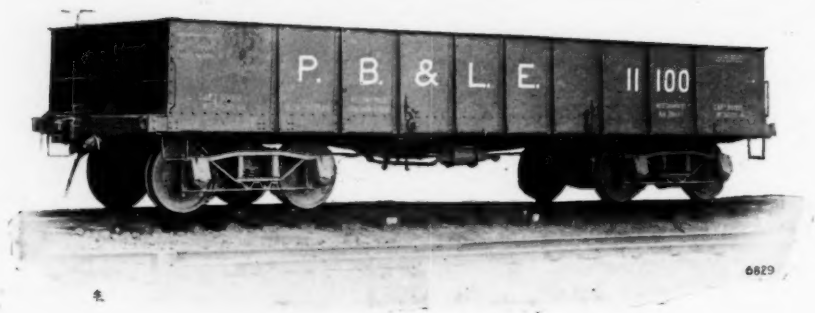
Pittsburg, and these had been subjected to a rigid service and careful inspection in order to determine their merits and demerits. But the railways hesitated to take the plunge, although really thinking that the car was a good thing. In short, the officials lacked the courage of their own convictions.

It was not until 1897 that the first real advance, from a commercial standpoint, was made. In that year, designs for an ore car of 100,000 lb. capacity were prepared by the Carnegie Steel Company for the Pittsburg, Bessemer and Lake Erie R.R. As would be naturally surmised, a design emanating from such a source was based almost exclusively upon the use of plates and rolled shapes. The management of the road, however, was not wedded to that form of construction. It had an exceedingly heavy ore traffic to handle between Lake Erie and Pittsburg. It realized that a high capacity car was an indispensable essential to the doing of the work economically, and that such a car must be made of steel. So when bids were asked, the manufacturers were invited to quote on competitive designs. Among those so submitted was that of Mr. Chas. T. Schoen, who offered one in which the framing was composed of steel parts. This was accepted, and an order placed for 600 cars. The general manager and vice-president of the road at that time was Mr. J. T. Odell, and to him is due the credit of grasping the situation firmly, of giving a physical demonstration of what many believed, and of demonstrating, on a commercial scale, the true value of the steel car as a potent factor in the transportation of bulky material.

The car fulfilled the most sanguine expectations of its promoters that rust was not the potent enemy that had been feared, and that a wreck did not involve the total destruction of the whole is well known. To be sure rust did prove itself to be troublesome. Where cars were used as warehouses for the storage of coal, especially that containing a large percentage of sulphur, the plates were soon eaten through. But where the car was used merely as a vehicle of transporta-



STEEL FRAMING FOR BOX CAR, NORFOLK & WESTERN R.R.



FLAT BOTTOM PRESSED STEEL GONDOLA CAR.

tion, and was promptly unloaded at the end of the run, rust gave no great amount of trouble.

As for the effect of wrecks, even the most sanguine advocates of the steel car were surprised at its performances. It proved itself a formidable object in a train; it sustained shocks that would have converted a wooden car to kindling wood, and that, too, with such a slight distortion of its parts that it is surprising to find with what meagre appliances the repairs can be made. Indeed, there are very few railways in the country that have even yet made any extensive provision for the repairing of steel cars. As a matter of fact, the ordinary equipment repair for the work consists of little more than an oil furnace for heating, shears and punches for shaping, and flanging and straightening anvils for such hammer work as may need be done. It is not claimed, however, that this is all that is desired, and more extensive appliances will undoubtedly be installed in many places before long; but this small outfit can be made to serve the purpose, and serve it well.

As already stated, attention was first paid in the development of the steel car to the gondola and hopper bottom types for coal and ore. As it proved itself suitable for this service the steel underframing was next applied to other purposes, and the box car with this feature soon appeared. In this connection the work done on the Pennsylvania R.R. may be taken as typical of the progress that has been made. Although steel cars had been built for this road as early as 1887, they were for special purposes, and it was not until 1897 that the introduction of steel cars was seriously undertaken at about the same time as upon the Pittsburg, Bessemer and Lake Erie, as already noted. Since that time, flat, gondola, hopper bottom, and box cars have been built in ever increasing numbers until there are now in service upon this line alone nearly 50,000 cars either wholly of steel or having steel under-framing. The type that has come to be recognized as the most common construction has pressed steel sills and other parts. In the case of box cars, the majority have the upper framing of wood, though many with steel posts and braces are built. No substitution has yet been found for wood in the sheathing and roofing, and that will continue to hold its own for some time to come.

Thirty years ago, when the development of the modern freight car may be said to have begun, there was an equality between the paying and dead loads of the car. As the capacities were increased, this ratio became greater until with the capacity of 60,000 lb. the paying load was about twice that of the dead. With the introduction of the steel car a still further increase has been effected until at present there are cars in service having a rated capacity of 100,000 lb., whose total weight, including trucks, is but

30,610 lb., or with a ratio of about 3⅓ to 1. In the case of box cars, the ratio is somewhat less, that of the 36 ft. car of the Pennsylvania railroad being about 2½ to 1, or actually with a total carrying capacity of 110,000 lb. the dead weight is but 44,840 lb.

It is evident, then, what an economical advantage the high capacity steel car presents when placed in comparison with the wooden car. Its growing popularity seems to foretell the gradual disappearance of the older and weaker type; a disappearance that is apt to be hastened, not only by the increasing cost of wood, but also by the fact that in road and yard service, as well as in veritable wrecks, the wooden car is being constantly damaged, and quite frequently, to a serious extent, by its juxtaposition to the steel car.

Mass Analysis of Muntz's Metal by Electrolysis.

AT the meeting of the Faraday Society, held on January 30th, Mr. John G. A. Rhodin presented an interesting and valuable paper on this subject, the reading of which was accompanied by experiments.

The first portion of the paper describes an apparatus which was specially designed by the author for the purpose of the accurate and rapid determination of the copper content (which should lie between 60.5 and 61.5 per cent.) of Muntz's metal. As about 40 to 60 "heats" of metal are cast every day, and it being necessary to obtain the results within twelve hours of the time of casting, the apparatus had to be such as to enable 100 analyses to be made in twenty-four hours —with a mean probable error of not more that ± 0.1 per cent. The author decided that an electrolytic method would best fit in with these stringent requirements.

The electrodes employed consist of concentric cylinders of very fine platinum gauze, supported by stout frameworks in order to ensure even current distribution. The anode rests on a ring at the bottom of the containing vessel, so that the cathode can easily be slipped away and removed, and both electrodes are held in modified Classen stands. The present installation consists of thirty of such unit cells, and current is supplied to them from six accumulators, each of which supplies current to five pairs of electrodes, through suitable nickelin resistances.

One gramme of the alloy, dissolved in nitric acid, is used for an analysis, and a current either of 0.5 amperes or else of 2.0 amperes is employed for the deposition. In the former case, deposition is complete in twelve to fifteen hours, in the latter in three hours. Electrolysis proceeds in three phases:—(1) Copper deposition and ammoniacal reduction of nitric acid. (2) Ammoniacal reduction only. (3) Deposition of zinc. A perfect separation takes place if phase (2) occupies a long time and is unaccompanied by metal deposition. If certain impurities, such as arsenic or nickel, be present they must be removed chemically. The paper describes in detail the actual procedure at the works laboratory, and also includes a table showing the kind of accuracy obtained in cases where re-analyses have been made. Since these analyses in bulk have been made, it has been found that they act as an infallible guide to the casters, so that re-melting has now become very rarely necessary.

In conclusion, the author discusses the electrochemical properties of Muntz's metal. The metal is largely used as a sheathing to protect ships' bottoms from certain mollusca and algæ, and to be successful it should dissolve in sea-water just to a sufficient extent as to render the surface poisonous, the best conditions being the equal dissolution of the copper and zinc. The author shows how these may be calculated approximately by supposing that the electrolytic dissolution rate is proportional to the heat of formation of the ultimate compounds (zinc and cuprous chlorides), and to the conductivities of the metals which dissolve. Assuming that both the chlorides of copper are formed, and taking the mean of the results in the two cases, the best values are found to be 60.811 per cent. of copper, and 39.189 per cent. of zinc, numbers which agree very closely with the results of practical experience. The author is now engaged in exhaustively investigating the *absolute* dissolution-velocity of pure Muntz's metal at a definite temperature; and he adds here a preliminary description of these experiments, describing in an appendix his most recent experiments on the subject.

XUM

A Study of the Causes of Coast Erosion.

By Dr. JOHN SWITZER OWENS, B.A., A.M.Inst.C.E., F.R.G.S., etc.

(Second Article.)

WE now pass on to the consideration of tides as they affect the coast.

As is well known, the tides of the ocean result from the attraction of the moon chiefly, and also of the sun. It is unnecessary for the present purpose to go minutely into the history of the tidal wave from the time it is generated in the Southern Ocean until it, or rather secondary offshoots from it, reach our coasts. I suppose the most complete information on the tides in any book extant is to be found in the treatise published in the "Encyclopædia Metropolitana," and written by the Late Astronomer Royal, Sir G. B. Airy.

For our present purpose it is sufficient to consider the tide under two headings: (1) The effect of the slow rise and fall of the water-level, and consequent travel of the water's edge up and down the foreshore; (2) The effect of currents and eddies set up, owing to difference of water-level at different places.

Taking the first of these, we may dismiss the slow landward and seaward *current* as being too slight to have any effect in moving material unless the very finest. There is, however, another effect which is due to the travel up and down of the breaking point of the waves, and this is most important, as whatever action is going on at the time, due to the breaking waves, is applied successively to different parts of the foreshore, between H. and L.W.M., whether it be erosive or the reverse.

If the tide rose and fell at a uniform rate, independent of the state of the tide, the result would be to plane out a uniform gradient between the breaking points of the waves at H. and L.W.; but this is not so, since the rate of rise or fall is very much faster at about half tide level than at either H. or L.W., hence the planing action is applied longer to the parts of the foreshore about these points than about mean sea-level, and whatever erosive or accumulative effect is being produced by the waves, is most marked just below H.W.M. and just above L.W.M. The bearing of this consideration upon the length of groynes is obvious, as it indicates that they should extend from above H.W.M. to below L.W.M.

When waves parallel to the shore are eroding it, the above consideration shows that the result will be to cut out a section of foreshore something like that shown in Fig. 4, a hollow being dredged at *A* and *B*, and corresponding hills produced seaward of each hollow; whereas, if the waves were accumulating, this effect would be reversed, hills taking the place of the hollows, and *vice versa*.

Taking now the effect of tidal currents, we come to a much disputed question. These currents are usually parallel to the shore, except when the coast-line is very irregular, and their effect is probably simply to transport material already suspended or disturbed by wave action. Except where concentrated by narrow straits, etc., they are not usually sufficiently swift to move material of themselves. These currents are, however, most efficient in carrying away matter suspended by wave action, or swirls, or eddies due to a very rough bottom; and their preponderating effect, in determin-

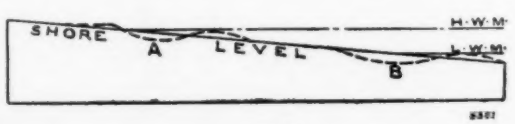


FIG. 4.

ing the direction in which material eroded from the coast is transported, is shown very clearly by Mr. Wheeler in his book on "The Sea Coast," where he shows the great tendency for sand-pits at the lee of headlands to point in the direction of the flood tide independently of the direction of prevailing winds. Consider the linear oscillation of unbroken waves on the bottom when a tidal current is flowing along shore. This linear movement must necessarily become a zig-zag, each oscillation being deflected by the current, so that the path of particles on the bottom, which are being oscillated to and fro, becomes an along-shore movement, something like that we have considered under "Oblique Waves," and as shown in Fig. 5.

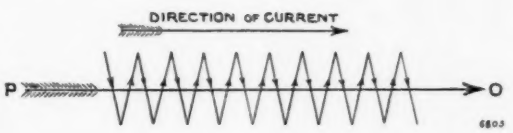


FIG. 5.

A current flowing in undisturbed stream-line motion is, in my opinion, quite incapable of transporting suspended material any distance, or of picking up matter from the bottom. A particle of sand thrown into such a current would sink at the same rate as in still water. Of course, such a current is merely ideal, but the consideration suggests the importance of swirls and eddies in picking up and holding matter in suspension, and conversely the advantage of reducing such swirls and eddies if we wish to encourage deposition. The effect of eddies is, however, sometimes to cause deposition, as will be considered later.

In the next article we shall complete the consideration of the active eroding agencies and go on to the study of the various factors which influence the effect of these more active agencies.

Dr. Cornish's observation of the movement of sand by currents* led him to the conclusion that there was a certain critical velocity of current, which, when passed, caused the bottom layers to become thickly charged with sand in "eddying suspension," with the sudden formation, at the same time, of sand waves of a remarkable character, having a wave length of from 3 ft. to 20 ft., and a height equal to one-twentieth to one-fourteenth of the length. These waves having the peculiarity of travelling *against* the current by the transference of grains from the face of one to the back of the adjoining wave, the actual movement of the sand itself being with the current. I have myself observed these waves in process of formation, and have come to the conclusion that when the velocity exceeds a certain point, there is, for some reason, a sudden generation of eddies or swirls in the bottom layers, which previously were moving in approximately "stream-line motion."

It must not be forgotten that the direction of flow of a surface current is not necessarily an indication of the direction in which the water is moving along the bottom. In the shallow water near the coast, the probability of the existence of bottom currents having a direction independent of that of the current observed upon the surface, is not so great as in the deeper water seaward. Still, that such currents are possible, even in the shallowest water, is certain. I have myself observed a well-defined bottom current and an equally well-defined surface current, flowing in diametrically opposite directions, in water of not more than 1 ft. in depth.

It will be clear that, should such currents exist, their effect upon the bottom will necessarily be quite independent of that of the more superficial currents, and vastly more important. Our knowledge of the bottom circulation of the sea is of a very meagre description, and is

* "On the Formation of Wave Surfaces in Sand," by Vaughan Cornish, M.Sc. (Vict.), F.C.S., F.R.G.S.

derived chiefly from soundings taken in connection with the great submarine cables. Mr. Stallibrass, in his paper on "Deep Sea Soundings in Connection with Submarine Telegraphy," gives instances of such currents, and states that between the Canary Islands there are strong currents 1,000 fathoms below the sea face, and that their scouring action may be clearly detected. In this case, I believe the existence of such currents is an inference from the behaviour of the sounding line, and the "scouring action" an inference from the absence of silt.*

As to the velocity of current required to move material, the smaller the grain the lower is the velocity which suffices to transport it. The following interesting table of values for different sized particles is taken from Mr. Jukes Browne's "Physical Geology":—

Current of	3 in	per sec. moves	fine clay or silt
,,	6 in.	,, ,,	fine sand
,,	8 in.	,, ,,	particles the size of peas
,,	1 ft.	,, ,,	pebbles as large as beans ($\frac{1}{2}$ in.)
,,	2 ft.	,, ,,	pebbles 1 in. diameter
,,	2·82 ft.	,, ,,	,, 2 in. ,,
,,	3·46 ft.	,, ,,	,, 3 in. ,,
,,	4·00 ft.	,, ,,	,, 4 in. ,,
,,	4·47 ft.	,, ,,	,, 5 in. ,,
,,	4·90 ft.	,, ,,	,, 6 in. ,,
,,	5·29 ft.	,, ,,	,, 7 in. ,,
,,	5·65 ft.	,, ,,	,, 8 in ,,
,,	6·00 ft.	,, ,,	,, 9 in. ,,

Wind.—We now pass on to the consideration of the wind in its effect upon the coast. The action may be either *direct* on the material of the shore itself, or *indirect*, the result being in the latter case attained by the intervention of the sea through the medium of waves and currents, or the raising of the surface level locally by the surface friction between the water and the air currents.

It is to the direct action of the winds that we owe the formation of the great sand dunes to be found in many parts of our coast, especially where large surfaces of fine sand are laid bare at L.W. In such cases I think it may be inferred that the general tendency of the sea is to recede, although under special circumstances, when there is a combination of unfavourable factors, such as very high tides and heavy on-shore winds, erosion may take place. Such a shore is to be found round the Wash and the adjoining coasts. The sand thus carried by the wind is only of the very finest, and, contrary to what would be expected, it is picked up from the wet surface of the foreshore—in fact, it is only when the surface of the sand is so wet as to show a distinct reflection that the wind is incapable of picking up and carrying away the surface particles.

The action of the wind, however, in producing waves, currents, etc., is of vastly greater importance from our present point of view. Waves have been dealt with in Article No. I., and although there are many interesting points which might be discussed profitably in this connection, it is not possible to go into them in the space at my disposal. We will therefore consider

Currents Produced by the Wind.—Such currents are primarily a surface drift with the wind. This surface drift, however, by bringing water from one point to another, tends to raise the surface level at the latter, and to maintain the equilibrium it becomes necessary for water to be removed, otherwise the result would be a great rise of surface level. This rise actually takes place to some extent before a sufficient difference in *head* is produced to cause the balancing out-flow, and the actual rise in surface level depends upon the facility with which the influx of surface drift can be counterbalanced by an out-flow elsewhere, either as a bottom current, or, when the wind drift is of small width compared with the sea or bay under consideration, the escape may take place by a parallel current flowing back alongside the primary current. When, however, a strong wind is blowing into the mouth of a more or less land-locked sea, such as the North Sea, and the force of the wind is so great as to drive water before it faster than it can escape elsewhere, disastrous consequences may result from the rise of level produced, especially if this state of affairs occurs on the top of H.W. springs.

*Mr. Buchanan in discussion on the above paper by Mr. Stallibrass.

XUM

FIG. 6.—THE NESS, TEIGNMOUTH, SHOWING THE ACTION OF "OBLIQUE WAVES."

The effect of the wind depends upon its velocity, direction, and, to a very great extent, upon its duration. When a strong wind blows on the surface of the sea for some time it generates waves, and these give the wind a better grip of the water, and make it more effective in producing currents. With a wind blowing dead on-shore, it is generally noticed that a denudation of the shore takes place, and conversely with a wind blowing off-shore, a building up or accumulative action usually goes on. This may be explained as follows:—With an on-shore wind we get a surface drift shorewards and an under-tow seawards. At the same time we get very rough, high seas, the water being disturbed and churned up by the waves into a boiling and eddying mass for a great distance from the shore; the waves break further seaward, and are also forced shorewards by the wind, having their frequency of impact increased. There is no time for the regular sequence of plunge, up-rush, and back-wash to take place, but the waves hurry in one on top of the other, and a "surf" is formed. The character of the wave also alters from an oscillatory to a translatory, at a considerable distance from the shore, the whole surface being often composed of water projected shoreward by the breaking of the waves, thus aggravating the surface drift due to direct wind action and consequently the under-tow seaward.

Now, in this state the sand is churned up into suspension for a great distance from the shore, and naturally the quantity in suspension is greatest near the bottom where the under-tow is at work bringing the water seaward, where the sand is again deposited as the disturbance gradually subsides in the deeper water.

The under-tow must also assist the oscillation of the water particles due to the unbroken waves to carry material seawards, by opposing the landward and assisting the seaward swing. Thus we get a state of affairs eminently favourable for erosion. Should the wind now suddenly veer or back, so as to blow off-shore, before the disturbance has abated, it will at once tend to generate a surface drift *seawards* and an under-tow *landwards*, and, should the sea remain rough,

the conditions would be most favourable for accumulation; but this wind speedily destroys the waves near the shore, which were developed by the on-shore wind, and thus there is no disturbing element to churn the sand into suspension, and the opportunity for accumulation is not so good as that of the on-shore wind for erosion, also the material moved under the influence of an off-shore wind will be of an altogether finer nature for the same reason; it is therefore at a disadvantage in this respect also. There appears to be, all things considered, a greater tendency to the transport of material seawards than landwards, with exceptions in favour of special places, such as Dungeness.

With a wind blowing along-shore, not only is the "oblique wave" effect developed, but there is also an actual drift of the water with the wind, which, in the shallow water within the sphere of wave action, is most effective in causing an along-shore travel of the smaller particles of sand, shingle, etc. With such a wind we therefore get accumulation on the windward and erosion on the lee of any obstacle which is capable of intercepting this drift. Hence the huge accumulation to the windward of high groynes, jetties, etc., and the almost invariable scour at the lee.

The effect of atmospheric pressure upon the surface level of the sea is very marked, a rise in the barometer causing a depression of surface level and *vice versa*, the water being forced by the weight of the superincumbent air from the areas of high pressure into those of low pressure. It has been estimated that 1 in. of rise in the barometer produces a depression of the sea of from 7 in. to 13.4 in.*

If we have such a set of coincidences as the following—a low barometer, high spring tides, a high wind blowing from such direction as produces the heaviest seas in any particular place—and if this

* Lubbock and Bunt.

FIG. 7.—GULL ROCK, KYNACLE COVE.

The waves are seen hurried in by an on-shore wind. A reflected wave is coming across from the left, and in the angle between this and the incoming primary wave is seen the back-wash of a previous wave running seaward. Note the thin line of foam rolled up when this back-wash meets the incoming wave, and showing clearly the seaward current diving under the landward and separating it from the bottom.

FIG 8.—NATURAL ARCH, TORQUAY, SHOWING THE STRANGE FORMS IN WHICH THE SEA CARVES THE SOLID ROCK.

wind which produces the heaviest seas coincides in direction with that which tends to produce the greatest rise in water level at that place, we have a combination likely to result in disaster, wrecking of sea-walls and other defences. Fortunately, this latter coincidence in direction does not always occur, and we often get a smooth sea with an exceptionally high tide due to wind action. But where it happens that the wind which tends to raise the surface level also tends to produce the roughest sea, more serious results may be looked for in that place than where these two effects are produced by winds from different directions, which obviously cannot both blow at the same time. We have here one explanation of the selective action of the sea in sparing some places whilst attacking others. There are, of course, many other reasons why different parts of our coast do not all suffer alike.

Amongst other active erosive forces the effect of land water must be considered.

This is seen in the crumbling and falling away of cliffs due to springs and streams, and is very marked in the case of small streams which flow down the surface of the foreshore when the tide is out; such streams act as traps to intercept material which is being drifted alongshore, and carry it seaward, the channel being alternately silted up when covered by the sea, and scoured out when the tide is low and the stream is flowing across the foreshore. It is clear from this consideration that if, in reclamation work, it is necessary to carry the outfall of a sluice across the foreshore, it should never be done by means of an open run or channel, which will trap the sand coming from windward, silt up the channel, and at the same time cause a scour or erosion to the lee of such a run.

Mr. Wheeler, in his book on "The Sea Coast," invokes the aid of land waters to explain the existence of the large quantities of sand and shingle to be found around our coasts, and he describes the process as follows:—"At the close of the great Ice Age, the melting of the vast bed of ice and snow, estimated at several hundred feet in thickness, which then covered the country, must have led to immense torrents of water escaping seaward, carrying with them the *débris* from the rock surface, disintegrated by frost and broken up by ice sheets and glaciers, and besides leaving deposits of gravel in the valleys and on the surface of the land, carried the degraded material to the sea bed. . . . The deposit, after the wear and tear of the waves during long ages, resulted in the formation of sand beaches."

I cannot help thinking, however, that the enormous quantity of material eroded from the coasts during the formation of the "Continental shelf" is quite sufficient to account for the sand and shingle we now see.

Erosion of the coast results also from sub-aerial agencies such as rain, frost, chemical and other actions, as well as from the direct attack of the sea. The constant percolation of rain water through cracks and fissures tends to disintegrate the cliffs, and the action of frost is well known in pulverizing the surface and splitting off fragments.

Strange as the assertion may appear, it is nevertheless true that the sea in certain cases destroys the cliffs by fire. At Ballybunion, on the West Coast of Ireland, the cliffs at one time presented the appearance of a "burning mountain."

An extensive landslip had taken place; the alum and iron pyrites, which are contained in considerable quantities in these rocks, were exposed to the action of the atmosphere and sea water, resulting in a rapid oxidation and the development of sufficient heat to set the whole cliff on fire.*

A somewhat similar incident occurred on the cliffs opposite Weymouth, some years ago, but in this case the fire appeared to be due to the spontaneous combustion of the highly carboniferous shale occurring there.

The artificial removal of foreshore material for building and other purposes may also be mentioned as a cause of sea encroachment. If the foreshore is lying at its normal level, neither erosion nor accumulation going on, and shingle or sand is removed from any part, an immediate result of this is to cause a gradient sloping to that part from all around it, and a consequent feeding in of material from the adjoining foreshore to fill the place of that which was removed, so that the removal of this material from a foreshore belonging to one man may prejudicially affect his neighbour's property. I have known a case where a railway company made special rates to encourage the traffic in shingle from the foreshore adjoining their line, and some years after were compelled to go to great expense erecting sea-defences to protect their line from the encroachment of the sea.

Subsidence of the Land.—In this we have a very ready explanation of sea encroachment, much too ready, in my opinion, for many people jump to the conclusion that when encroachment is going on, subsidence of the land is the cause. It is naturally very difficult to detect such subsidence, if it is general, owing to the lowering of "bench marks," and conversely, to prove that it does not exist in any particular place for the same reason.

That great fluctuations of level of the land surface have occurred in past ages is a well-established fact, and it seems probable that such changes of level of the land relative to the sea are still going on, slowly as measured by our time units, but possibly rapidly as regards geological time.

The evidences of a previous submergence of the land are very widespread, and consist of "raised beaches" occurring at great height above the present sea level and also of marine shells and deposits in elevated positions, etc. The vertical movement of the land did not occur all at one time, but there were

* See "The Ocean," by E. Reclus.

periods of movement followed by periods of quiesence; this is shown by the various heights at which "raised beaches" are to be found, *e.g.*, in Scandinavia they are to be found at heights of from 200 ft. to 500 ft. above the sea. In Finmark, along the Altenfiord, there are terraces at successive levels of 56 ft., 65 ft., and 143 ft. They exist at Portland, Selsey, and Brighton; and in Scotland, four, and even five, sometimes occur in terraces, one above the other, at heights of 25 ft., 40 ft., 60 ft., 75 ft., and 100 ft. above present H.W.M.* Along such ancient sea margins caves are sometimes met with, excavated by the sea in prehistoric times.

The evidences of elevation at some previous time, and subsequent submergence, are to be found in the "drowned" river valleys, which form a continuation of many existing river valleys—notably, the Congo—and cut right across the great Continental shelf at a depth of 100 to 200 fathoms below the present sea level. These valleys were undoubtedly eroded under terrestrial conditions.

Evidences of depression are also to be found in submerged forests at several parts of the coast of England and Wales, and also in Ireland, and also in beds of peat uncovered by the sea at L.W.

I have myself come across beds of peat 6 ft. thick on the foreshore at Youghal. Ireland, with branches and trunks of trees embedded in it; also at Deal, peat is to be found under the foreshore, and at Borth, Wales, I have seen an extensive bed of peat exposed at L.W. having the remains of an old forest embedded in it, the trees all standing upright as when growing, but being broken off at a short distance above the shore level. There are many other such examples which might be mentioned, but the above will be sufficient. An interesting consideration which might here be mentioned is that the elevation of any part of the sea bottom must cause a corresponding displacement of the water, and if the area elevated be extensive enough, it will appear to us as a subsidence of the land, but such subsidence would be universal, and of equal amount everywhere. Such elevations of the sea bottom undoubtedly take place, but their effect must be small when compared with the great vertical movements of the land itself.

A very interesting explanation of the causation of oscillations in level of the earth's surface is given by Mr. Reade,* who considers that such changes in level are due chiefly to the deposition of sediment on the sea bottom. This sediment is derived from the degradation of the land surfaces, sub-aerial erosion, and coast erosion. Sub-aerial erosion of the land surfaces, going on at the rate of approximately 1 ft. in 4,000 years, produces in time a large amount of detritus, which is carried out to sea by rivers, partly in suspension, partly in solution (the proportion being about 3 in suspension to 1 in solution).

On reaching deep water, most of this is deposited. Now, when it is remembered that the earth's temperature increases at the rate of about 1 deg. F. for every 50 ft. in depth below the surface, it follows that the blanketing of the surface by sediment causes a rise in the isothermal lines, or surfaces, the old surface gradually rising in temperature as the deposit thickens, with consequent increase in volume and variation in specific gravity, giving rise to gliding of the crust, folding and rise in level.

There are, of course, other causes of changes in level, such as differential alterations in volume of large sections of the globe, owing possibly to chemical as well as thermal and physical causes imperfectly understood.

In my next article I will give a short account of some of the more important factors, which, while not in themselves active, exercise a powerful influence upon the effect of the more active forces, such as waves, currents, etc.

* See "Physical Geology," by Jukes Browne.

* "The Evolution of Earth Structure," by T. Mellard Reade.

I am indebted to the courtesy of Mr. J. C. Inglis, M.Inst.,C.E., General Manager of the Great Western Railway Company, for the photographs which illustrate this article.

Some Conditions Governing the Production of Iron and Steel Castings.

By PERCY LONGMUIR.

I.

Cast Iron.

SEVERAL years ago the replacement of cast iron by steel was current prophesy in various foundry circles. To-day these prophesies are no nearer completion than when first uttered, and he would be a bold writer who, in the light of present knowledge and past experience, dare foretell the entire replacement of cast iron by steel. Such conditions will be realised when a *commercial* method for the direct production of steel from iron-ore is evolved. Until such a consummation the economic value of cast iron will powerfully appeal, as hitherto, to the engineer. It will therefore not be without interest to review some of the more salient features governing the production of iron castings. As a starting point an average type of cast iron familiar to an engineering foundry is given in the table below:—

Analysis.						Tensile Strength. Max. stress. Tons per sq. in.	Transverse. Bar 3 ft. Cwts.
Combined Carbon.	Free Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus.		
0·50	3·20	1·75	0·50	0·05	1·2	12 to 15	28 to 35

Influence of Composition.—Naturally, the first consideration will be that of composition, and the most convenient method of examining this influence is found in a structural rather than a purely chemical direction. From the analysis just given it will be noted that constituents other than iron reach a total of 7·2 per cent., and it may be further stated that this iron is perfectly typical of the general run of engineering castings. Cast iron is therefore far more complex than steel: structurally it consists of a matrix of pure iron, and distributed through this matrix are varying amounts of carbon, carbides, sulphides and phosphide of iron.

A perfectly pure iron would in mass be built up of crystals which sectionally present a series of crystal junctions, as in Fig. 1. If to this pure iron 3 per cent. of silicon is added, no distinct structural change is shown; in all probability the silicon combines with some of the iron to form a silicide, and this silicide is held in solution by the iron.* On the other hand, if 4 per cent. of carbon is added to pure iron, a distinct structural change is manifested, and an entirely new product is obtained. An examination of Fig. 2 will convey some idea of this change.

These structures, pure iron and white cast iron, at once give a clue as to the dominant influence of composition, for the chief controlling element is that of carbon. So far as cast irons are concerned, the amount of carbon present is not so important as its condition. The total carbon of a foundry iron is divided between the two conditions of "free" and "combined," the first condition representing the only constituent of a cast iron existing in the free or uncombined state. Free carbon or graphite has a mechanical influence only, whilst combined carbon has a pronounced chemical effect on the iron. Reverting for one moment to Fig. 1, if carbon is added to the iron, or ferrite, a combination occurs between the two, resulting in a definite carbide. With a content of carbon below 0·9 per cent., this carbide or cementite is always intermingled with ferrite, both being in a fine state of division. This mixture of ferrite and cementite is termed pearlite. Accord-

* This view is more tenable than the assumption that *silicon* is held in solid solution.

ing to the conditions of cooling, pearlite may be either fine or coarse. In other words, slow cooling permits the constituents of pearlite to segregate, and conversely quick cooling retards this segregation. Two types of pearlite are shown in Figs. 3 and 4, the former representing segregated, characterised by its laminations, and the latter unsegregated pearlite. When the content of carbon exceeds 0·9 per cent., in addition to its presence in pearlite, cementite is found structurally free. Obviously iron carbon alloys will consist of two constituents: (*a*) when the carbon is below 0·9 per cent. of ferrite and pearlite, and (*b*) when the carbon exceeds 0·9 per cent. of pearlite and cementite. Actually at 0·9 per cent. carbon the structure consists entirely of pearlite, and such a steel is termed by Professor Arnold, "saturated." Steels containing free ferrite are termed "unsaturated," and steels containing free cementite "supersaturated." These terms, whilst applicable chiefly to steels, have yet a direct bearing on cast iron, the value of which will be seen presently.

From the foregoing it is evident that the structure of Fig. 2 is practically that of a highly supersaturated steel and may be described as pearlite (black) embedded in a ground work of cementite (white). Even at a high magnification these pearlite areas are not resolved so clearly as is the pearlite of Fig. 3; and an examination of Fig. 5 will show that in this white iron pearlite has not distinctly segregated, but is more nearly related to that of Fig. 4.

It has been stated that silicon to the extent of 3 per cent. added to pure iron produces no distinct change in the structure, but if this quantity is added to white cast iron a remarkable change is at once obtained. In other words, if silicon is added to molten white iron the resulting product is more or less "grey" according to the amount of silicon present. A grey iron is soft and

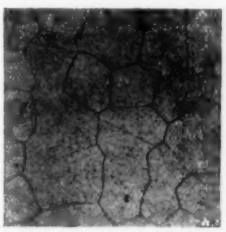


FIG. 1.—FERRITE × 150 DIAMETERS.

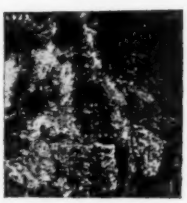


FIG. 3.
SEGREGATED PEARLITE.

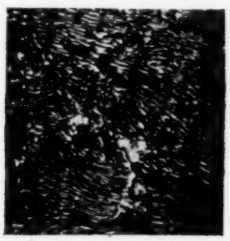


FIG. 4.—UNSEGREGATED PEARLITE.

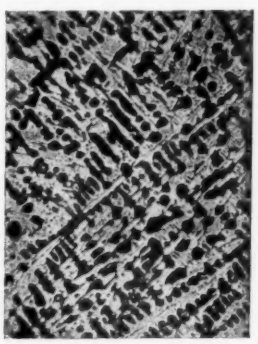


FIG. 2.—WHITE CAST IRON SHOWING PEARLITE AND CEMENTITE × 150 DIAMETERS.

FIG. 5.—WHITE CAST IRON × 1,000 DIAMETERS.

readily machined, whilst a white iron is extremely hard and cannot be touched by ordinary tools. Within limits the higher the silicon the greyer the iron, and, conversely, the absence of silicon results in a white and consequently hard iron. Therefore, silicon added to a white unmachinable iron results in a casting which readily lends itself to the operations of turning or drilling.

From the foregoing it would appear that silicon, rather than carbon, is the element ruling the destiny of a cast iron. Such, however, is not the case. The softening action of silicon is due, not to any influence on metallic iron, but entirely to the influence of silicon on cementite. The presence of silicon in a cast iron prevents the formation of cementite, hence the cold product contains free carbon and free iron. Free iron, or ferrite, is distinctly soft and ductile, and in this respect almost equals copper. On the other hand, cementite is distinctly hard and brittle; pearlite, being a more or less intimate mixture of two dissimilar substances, will evidently possess intermediate properties between the two. In other words, the hard and brittle cementite is to some extent neutralised by the adjacent ferrite, and conversely ferrite is stiffened by the tiny particles or plates of cementite. Free carbon represents flakes of graphite, which of course are distinctly soft; the vital point is, however, that these soft flakes of graphite have not the remotest softening influence on the iron. Graphite alone cannot produce softness, it has no chemical influence and its action is entirely mechanical.

These remarks are necessitated owing to the view sometimes advanced that graphite and silicon are softeners. The facts are that the former is entirely inert, and the latter certainly does not soften iron, but retards the formation of a hard constituent.

A comparison of Figs. 2 and 6 will illustrate this action of silicon on cementite. Fig. 6 represents the same iron as that of Fig. 2, melted with the addition of 3 per cent. silicon and cast into a ½-inch diameter bar. The photograph is taken from an unetched surface in order to show the graphite more clearly. Structurally, the mass now consists of ferrite, interspersed by wavy plates of graphite and some relatively small areas of pearlite. Combined carbon has fallen from 3·4 per cent. to 0·2 per cent., and the content of graphite risen accordingly. In its first condition the cast iron could hardly be touched by file or drill, whilst in its second, it is, in shop language, "as soft as butter." The total content of carbon is unchanged, silicon affecting merely the mode of existence and not the amount.

Manganese, unlike silicon, favours the retention of carbon in the combined form as cementite, hence tends to harden by its influence on the carbon. In the amounts usually present in foundry irons, this hardening action may be ignored, for it is practically neutralised by the silicon. The beneficial action of manganese is found in its leading to a sound iron of compact and close grain. Further, it neutralises sulphur by uniting with it to form a sulphide of manganese. Of the injurious influence of sulphur, it is unnecessary to write here, for that influence is universally recognised. It may, however, be briefly noted that sulphur promotes unsoundness, hardness, and leads to irons of very low strength. Structurally sulphur is never found free, but always as a sulphide of either iron or manganese. Sulphide of manganese, in reasonable quantity, has no harmful effect whatever, the bad influence of sulphur is always shown when it is in combination with iron. Fortunately sulphur appears to have a preferential affinity for manganese, hence in presence of this element the dangerous sulphide of iron is not so readily formed. Not only is this the case, but further manganese has actually a desulphurising effect. If the cupola charge contains two pig irons, one high in manganese and the other fairly so in sulphur, on melting some portion the manganese is slagged off and carries with it part of the sulphur. This advantage may be utilised when

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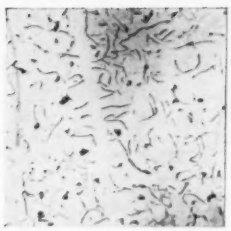


FIG. 6.—UNETCHED GREY IRON, SHOWING FINE GRAPHITE.

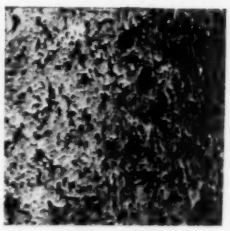


FIG. 9.—GRAPHITE IN CAST IRON.

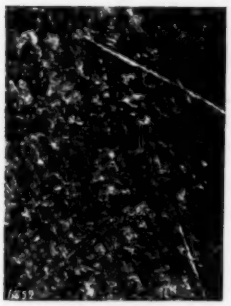


FIG. 10.

using a pig iron unnecessarily high in sulphur, by adding to the cupola charge a manganiferous pig, or manganese ore, or by adding manganese to the ladle previous to tapping, the last plan being effected by using crushed ferro-manganese of from 70 to 80 per cent. manganese content.

Phosphorus is, in cast iron, comparatively harmless in contents up to 1 per cent. It promotes fluidity, giving a clean running metal and one retaining the sharpest details of a mould. The phosphorus limit in castings, such as machine details, gearing, etc., which have more or less shock to meet, should be low and certainly not above 0·5 per cent. The general run of castings may contain up to between 1 per cent. and 1·5 per cent.; the latter figure, however, should mark the danger limit. Phosphorus combines with iron forming a definite phosphide, a compound which apparently does not separate out in normal grey irons. However, though in grey irons the compound cannot always be distinguished, the areas containing it are readily recognised by their eutectic type of structure. Thus Fig. 7 reproduces typical phosphide eutectic of a grey iron, a flake of graphite will be noted in the centre, and the rest of the structure is comprised of pearlite. When in excess, this phosphide eutectic tends to take a cellular structure enclosing pearlite as shown in Fig. 8. Such a structure is apt to prove brittle under shock, for if the cell walls are at all continuous they offer a favourable route for the passage of fracture.

Control of Composition.—Having indicated the salient influences of composition, next in order comes the application of these influences in routine foundry practice. Although at first sight this application may appear difficult, it is in reality exceedingly simple, and practically amounts to controlling one constituent only, viz., that of combined carbon.

Many castings are made which, if a faithful replica of the pattern, meet all requirements, and such castings require no subsequent work. On the other hand, quite a large output of many foundries is found in castings whose chief requirements lie in truth to pattern and softness, that is castings which may be machined to size at the lowest possible cost, and in which strength is

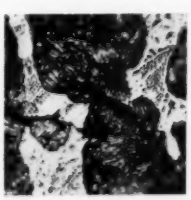


FIG. 7.

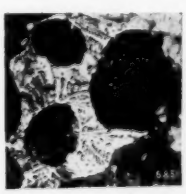


FIG. 8.

PHOSPHIDE EUTECTIC × 1,000 DIAMETERS.

immaterial. Such a casting must contain the minimum of pearlite, its structure will, therefore, be formed of siliceous ferrite broken up by plates of graphite. The total carbon of any given iron being always constant, or practically so, it follows that a change in carbon conditions, as, for instance, an increase of the areas of pearlite, is necessarily associated with a decrease in the amount of graphite. As the pearlite areas increase, hardness, tensile, transverse and crushing strength also increase, reaching a maximum when the structure consists of pearlite and graphite. On the appearance of free cementite, hardness rapidly increases, reaching a maximum with the unmachinable type of structure shown in Fig 2.

Engineering castings coming within the limit of economical machinery should, therefore, contain little or no free cementite. The requisite range of properties can be readily obtained by varying the ratio of ferrite to pearlite. A structure consisting of siliceous ferrite and graphite is—for cast iron—relatively soft and easily worked by tools.

The maximum mechanical properties are associated with a structure containing no free ferrite, but built up of pearlite and graphite. Obviously intermediate types of structure represent intermediate properties, and, although the hardness increases with each increment of pearlite, an economical working limit is not exceeded until free cementite is present.

The desired type of structure may be obtained by (1) regulating the rate of cooling from high temperatures, or (2) by the action of silicon in retarding the formation of cementite. The former is impracticable with ordinary castings, but in certain cases has a valuable field which will be referred to later. The second method is not only absolutely reliable, but has the further advantage of simplicity. The iron-founder may, by regulating the silicon content of his mixture, obtain perfect control of the combined carbon content of the resulting castings. One example of this action of silicon has been given, and it will be remembered that the addition o some 3 per cent. precipitated practically the whole of the carbon as graphite. Rapid solidification to some extent favours the retention of carbon as cementite, hence Fig. 6 shows the powerful action of silicon under adverse conditions, for a small casting ½ in. diameter cools with relative rapidity. Under the same adverse conditions—that is, casting into rods of ¼ in. diameter—the following experiments were made in order to test the action of small quantities of silicon on the state of the carbon in the cast iron shown in Fig. 2.

This iron is exceptionally pure, containing traces only of manganese, sulphur, phosphorus and 0·04 per cent. silicon. Cast in this condition, careful analysis detected no graphite. With silicon increased to 0·11 per cent. a trace of graphite appeared, viz., 0·06 per cent. Further increment of silicon 0·35 per cent., graphite registered 0·21 per cent., and with silicon at 0·45 per cent. graphite became 0·35 per cent. These results are of no value to the grey iron founder, nevertheless they are of high value in showing the influence of even slight additions of silicon on the state of the carbon. At the risk of repetition, it may be well to again state that the total carbon is approximately constant in quantity, hence an increase in graphite means a decrease in hard cementite.

Any reference to the action of silicon is necessarily associated with Professor Turner, whose researches, published in 1885, are of the highest value to all iron founders. Notwithstanding Professor Howe's recent dictum that "the rôle of silicon is not clearly known,"* Turner's results most forcibly demonstrate the action of silicon in precipitating graphite. These results may be daily corroborated in any iron foundry and are summarised briefly as follows:—

* "Iron, Steel, and other Alloys," page 210.

Property.	Content of Silicon per cent.
Maximum hardness	under 0·8
Crushing strength	about 0·8
Modulus of elasticity and density	,, 1·0
Combined crushing, tensile and transverse strength	,, 1·4
Tensile strength	,, 1·8
Softness and working qualities ..	,, 2·5

These silicon contents relate not to the influence of silicon on iron, but indicate an amount necessary to produce the required state of carbon. The following silicon standards have yielded excellent results in the writer's hands:

Type of Casting.	Content of Silicon per cent.
Malleable cast iron, thin section ..	1·0
,, ,, normal section	0·4
Chilled grey iron castings	0·75 to 1·0
High-pressure cylinders, valve bodies, etc.	1·3
General machine and engine details, gearing, etc.	1·5
Soft engineering and millwright castings, pulleys, etc.	2·5
Soft thin castings, stove grate and similar work	2·5 to 3·0
Hollow ware	3·0 to 3·5

Naturally, silicon standards must be adopted to meet individual requirements; the foregoing, however, offer a series suitable for selection. In mixing on a silicon standard, due allowance must be made for the silicon lost by melting. This loss averages about 0·2 per cent., but should be determined for each cupola.

Prominence has been given to combined carbon and its control by silicon, because herein lies the chief determining factor of the properties of cast iron. Other constituents have an influence which is associated with, or secondary to, that of carbon. Thus manganese, by favouring the retention of carbon as cementite, opposes the action of silicon and thereby "hardens." Sulphur also, by retarding the formation of graphite tends to harden and to produce brittleness. Therefore in the simultaneous presence of manganese and sulphur, the former element will actually have a softening influence by virtue of its desulphurising action already noted. Phosphorus is within the limits specified harmless, only becoming dangerous when, in castings having to meet shock, the phosphide eutectic takes the form of a connected network.

Summarising these secondary influences, it is always advisable to charge a mixture with as low a sulphur content as possible; ordinary engineering castings may, in the presence of 0·5 per cent. manganese, contain 0·1 per cent. sulphur with impunity, but this content should not be greatly exceeded. Of manganese 0·5 per cent. is an all-round useful content; in the presence of over 1·5 per cent. silicon, manganese up to 1 per cent. is safely permissible. An average phosphorus content is found at 0·75 per cent. with 0·5 per cent. for specially strong castings; 1 per cent. for the usual run of engineering and millwright castings and 1·5 to 2·0 per cent. for a free running iron, in which strength is of secondary moment only.

The Influence of Oxides.—Quite apart from composition, there are various factors which make or mar the casting. One of these influences is that of oxygen in the form of dissolved oxide, but whether it has any bearing on cast iron is a matter open for investigation. Melting atmospheres in ordinary cupolas are oxidising as shown by the oxidation of silicon and manganese. From the silicon standards given it will be noted that the bulk of grey iron castings made contain a minimum of 1·3 per cent. silicon. To this silicon must be added the manganese always present. During melting and whilst molten, these two elements would be oxidised before carbon and most decidedly before iron; the fact that grey iron castings always contain decisive quantities of silicon and appreciable amounts of manganese almost precludes the oxidation of iron.

With silicon exceeding 1 per cent. the writer has never met with faults in iron castings definitely due to the presence of dissolved oxide of iron.

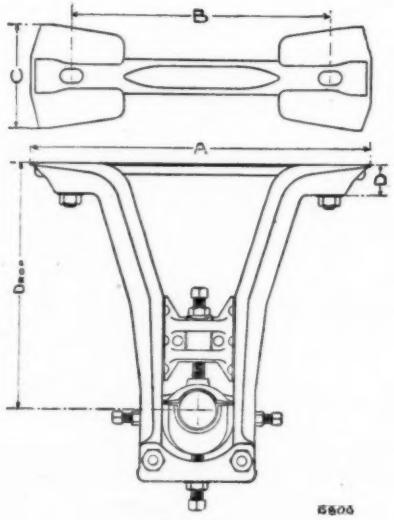
The Mechanical Influence of Graphite.—In concluding this section some refer-

ence to crystallised graphite is essential. It has been shown that graphite has no chemical influence on iron, but it has a decisive influence on the mechanical properties in that it destroys the continuity of the mass. For instance, in tension each flake of graphite acts to some extent, as a severance an effect naturally not so apparent in compression. The larger the crystallisation of graphite the more intense this weakening effect. One example of finely crystalline graphite has been shown in Fig. 6; a further one familiar to castings of 1 to 2 in. in thickness is shown in Fig. 9. Typical graphite of a pig iron is shown in Fig. 10, where it will be noted that several of the plates form practically straight cleavage planes. In comparing these three structures it will be noted that Fig. 6 is magnified 150 times, whilst Fig. 9 and 10 represent a magnification of 58 times.

Generally the smaller the castings the finer the division of graphite, but if the cooling is too rapid, graphite will not form and the castings are therefore hard, due to the retention of carbon as cementite. If a reliable method could be introduced for preventing the crystallisation of graphite, then an enormous gain in strength would accrue. Unfortunately such conditions cannot be attained with ordinary grey iron castings; the writer has made various endeavours in this direction, but has obtained no definite results. However, under certain conditions an exceedingly valuable product can be obtained by producing graphite in the non-crystalline form. These and other conditions will be indicated in a subsequent article.

Pressed Steel Hanger.

THE accompanying illustration is that of a new hanger, a sample of which was recently sent for our inspection by Messrs. Rimington Bros., of Carlisle, who are introducing it into this country. The main feature of the hanger is that it is, with the exception of the bolts and white metal, made entirely of drop forged steel parts, a method of construction which ensures a greater rigidity than is obtained in with cast-iron, at the same time effects a considerable saving in weight. The bearings are self-oiling and adjustable in every way, and, if preferred, the hanger can be reversed and used as a pedestal. Having regard to the dead weight which floors and ceilings are now called upon to carry, the introduction of this appliance marks a distinct advance, and as we are nformed it can be produced cheaper than the cast-iron article, it should receive the carefu] attention of millwrights.



HANGER.

House Drainage.

By GERARD J. G. JENSEN.

(First Article).

AMONGST the various matters affecting the sanitary condition of the modern dwelling-house there are few things of greater interest or more worthy of careful attention than the efficiency and safety of the drainage system. The intimate connection which exists between it and the physical well-being of those who reside within its immeditate sphere of influence has long been known, and is now—in this country, at any rate—widely acknowledged. Dainage is no longer regarded as merely convenience; it is now, rightly, looked upon as health. Whilst, fortunately, the one is not incompatible with the other, neither is possible unless the drainage system is perfect. It cannot, therefore, be too strongly insisted upon that everything relating to drainage should be of the best. Not only the general arrangement, but also the minor details and next-to-nothings must be as perfect as possible in design, material and construction, if health is to be maintained and recurrent inconvenience and outlay avoided. Moreover, the greater portion of the drainage system is out of sight when completed, and it is therefore all the more important and necessary that there be no doubt as to its efficiency.

The objects to be attained in carrying out a perfect system of house drainage may be tabulated as follows:—

(1) The primary disconnection of the house drains from the public sewer or other outfall.
(2) The secondary disconnection of rain and waste-water pipes from the underground drains.
(3) The thorough ventilation of the entire drainage system.
(4) The entire and immediate removal of all matter discharged into the drains, before decomposition is established.
(5) The provision of means of access for inspection and cleansing, &c.
(6) The construction of the entire system in such a manner as to preclude the possibility of the escape of gases or liquids into the house or its surrounding soil; and lastly,
(7) The provision of sanitary fittings which are sanitary, in fact, no less than in name.

Primary Disconnection.

The primary disconnection of the house drains from the public sewer, etc., is of the greatest importance, it being essential to exclude the aerial contents of the latter from all parts of the house and its drainage system. It is effected by the provision of an "intercepting" or "disconnecting" trap on the outlet of the drain at a point as near as possible to the sewer or other outfall. This trap is virtually a bend or dip formed in the drain, which, by retaining a constant volume of water, severs the direct line of communication between the piping on either side thereof, without causing any interruption in the flow of liquid. The water is said to "seal" the trap; whilst the phrase "a water seal of 2½ in." (the standard seal of a trap) denotes that the vertical dimension between the standing level of the water and the lowest point of the soffit at the dip is 2½ in. deep. The portion of water retained between these two points is that which actually seals the trap.

The essential points to be observed in selecting a trap for the above purpose are:—(*a*) That the trap be shaped as a syphon and be free of all nooks and corners which could favour the accumulation of deposits; (*b*) that, whilst providing an efficient "seal," the quantity of water retained be as small as possible, in order that it may be completely changed by

an ordinary discharge through the drain; (*c*) that the inlet to the trap be nearly vertical and such as to provide a drop of at least 3 in. between the discharge end of the house drain and the standing level of the water in the trap. This drop is of the greatest assistance in breaking up and driving through the trap such matter as may collect at its inlet. In addition to these *essential* characteristics, it is desirable that the trap be provided with a base or foot for stability, and it may also be advantageously fitted with a socket or arm giving access to the drain between it and the sewer in the event of obstruction. This arm must, of course, be closed hermetically by a removable cap or stopper. Good forms of disconnecting traps are shown in Figs. 1 and 2, whilst Figs. 3 and 4 illustrate insanitary types.

Trapping alone is not, however, a sufficient safeguard against sewer gas, since it has been conclusively proved that there are occasions on which such a trap will cease to be a "trap." Such, for instance, will be the case should the trap water remain unchanged sufficiently long to become impregnated with sewer gases, for under such circumstances the gases will be passed through readily. Again, in times of heavy rains, when the sewers are surcharged, the pressure within them may be sufficiently great to force gases through the water contained by the trap. It is therefore necessary to complete disconnection by making provisions for the immediate removal from the drains of any sewer gases which may pass the trap. This is arrived at by means of ventilation, of which more will be said.

Secondary Disconnection

The second object, viz., the disconnection of the rain and waste water pipes from the underground drains is arrived at by the provision of "gully traps"—also known as "surface traps"—under the outlets of the pipes. These traps are small disconnecting traps fitted with gratings on their inlets. Their object is to exclude from the rain and waste water pipes any gases which may be generated in the house drains.

As will be seen from the annexed sketches (Figs. 5 and 6), the pipes may be arranged to discharge either above or below the gratings of the traps. Both methods are satisfactory so long as the discharge from the pipes takes place *above* the level of the water contained by the traps. This is necessary in order that the outlet ends of the rain and waste water pipes may be left open to act as air inlets to the said pipes, the ventilation of these being necessary to complete their disconnection from the drains.

Surface traps must also be fixed on all otherwise open inlets to drains, such, for instance, as openings provided for draining yards, etc., of rain water, to prevent the escape of drain air at those points.

The chief characteristics of sanitary surface traps are not unlike those of disconnecting traps; that is, the traps must be formed as syphons; must be, as far as possible, incapable of retaining detritus, and must be provided with an efficient "seal" formed by a minimum quantity of water. They should also be formed with a suitable base, whilst a "hand-hole" on the drain ends of the traps will prove advantageous for access to the branch drains upon which the traps are fixed; these hand-holes will also assist in the making of good joints between the traps and the drains.

Ventilation.

The question of ventilation for the drainage system is one requiring the most careful attention. As has already been pointed out, ventilation is indispensable for the purpose of disconnection. Its object in connection therewith is to remove and liberate at a safe point any gases which may happen to pass through the traps, and which would otherwise be retained in the house drains.

Apart from this consideration, ventilation is, however, also necessary (*a*) for diffusing and removing any foul gases generated in the drainage system itself;

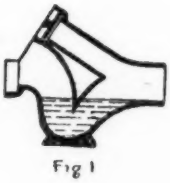


Fig 1

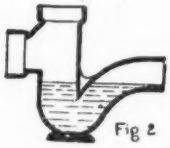


Fig 2

Fig 3

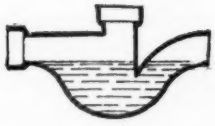


Fig 4

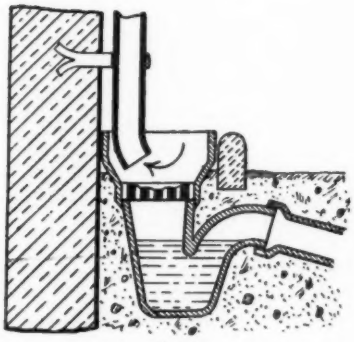


Fig 5

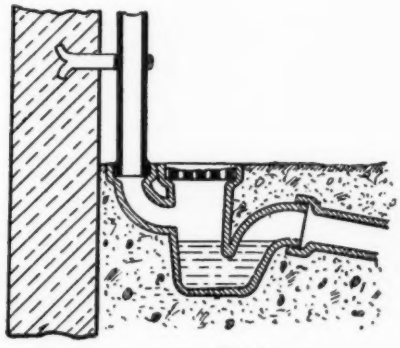


Fig 6

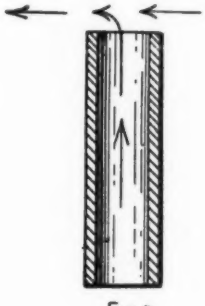


Fig 7

Fig 8

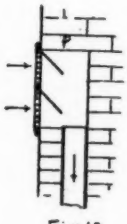


Fig 10

Fig 9

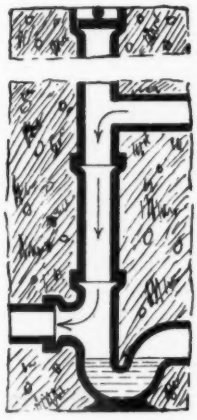


Fig 11 6839

(*b*) for the oxygenation and purification of the interior surfaces of the drainage system; and (*c*) for the oxygenation of the sewage passing through the drains, so as to retard its decomposition until it has been removed.

From what has been said, it will be obvious that each and every portion of the drainage system must be ventilated; that is, there must be a continuous passage or circulation of fresh air through the whole of the horizontal and vertical pipes forming the sanitary system. To accomplish this, there must be air inlets

as well as outlets. This is a point which by many is not thoroughly understood, and it is no infrequent experience to find cases of so-called "drain ventilation" in which outlet shafts have been provided without any corresponding means of ingress for air. To induce an air current by natural means, there must, moreover, be a considerable or, at any rate, an appreciable difference in level between the air inlet openings and those provided for the egress of the vitiated air. Unless this is the case, there will be a tendency to equilibrium and stagnation of gases in the drains, as the heavier gases—such as carbonic acid gas—will remain at the lowest points of the drainage system and virtually cause the formation of an air trap in the drain. As a general rule, it may be said that air inlets should be at or about the ground level, whilst the outlet shafts should be carried up to the highest possible points. Two or three feet above the ridge of the roof is usually a suitable position for the outlets of these pipes, if they are placed well out of the way of all windows, chimneys, and other openings into the house. There should be a minimum horizontal distance of some 20 ft. between such openings and the ventilation outlets, if tainted air and gases escaping from the latter are not to prove a source of danger and annoyance. The outlets should also be placed in as exposed positions as possible, in order that advantage may be taken of the prevailing winds for inducing or accelerating the air currents within the drains. The aspirating effect produced by a current of air passing across the aperture of a pipe at right angles (see Fig. 7) is too well known to require comment.

As a broad principle, it is very undesirable to provide either cowls or valves to the ventilation openings; the former are apt to invite stoppages by providing convenient cover and shelter for birds' nests, whilst the latter, unless constantly attended to, are very liable to fail and thereby either wholly close the openings or leave them open permanently.

Outlet openings should never be protected by any device other than an ordinary copper wire guard, such as shown in Fig. 8. This is the simplest and most efficient protection against obstruction of any kind. Inlet shafts may be similarly protected, unless their openings are at the ground level and in positions from which earth or detritus can gain access to the drains. In the latter case, the openings may be conveniently formed in some such manner as indicated in Fig. 9, as by its means all matter falling through the grating will be caught and kept from entering and obstructing the drains. Should a fresh air inlet, of necessity, have to be placed near a door or window, or in any other position where a reverse current would be undesirable, the opening may be filled with a mica flap valve (Fig. 10), which, whilst permitting an adequate admission of fresh air to the drains, will close against and prevent the egress of any air or gases issuing therefrom. These valves, however, require frequent attention, cleansing, and lubrication to remain efficient, and should therefore be dispensed with if at all possible.

In planning the ventilation of the underground drains, it is desirable that the air currents within them be arranged to travel in the same direction as that of the flow of sewage, in order that whenever a quantity of sewage is discharged the displaced air may be carried with it and passed up through the upcast ventilation shafts, thus assisting the circulation of air. As soil pipes from water closets, however, provide convenient and gratuitous outlet shafts, the system of ventilation must necessarily be greatly governed by their positions. Should, thus, the soil pipe be situated at the head of the drain (as is, more often than not, the case), the air inlet shaft must necessarily be provided at the lower or discharge end of the drainage system, in which case the air currents in the drains must travel in an opposite direction to that of the flow of sewage, unless local circumstances are such as will admit of the soil pipe being arranged as a low-level fresh air inlet. It is but seldom that this is the case, and it

is therefore generally necessary to provide the inlet at the outfall end of the drains, the air inlet shaft being conveniently branched into the disconnecting chamber, or into the shaft of the disconnecting trap (as in Fig. 11), where no chamber is provided.

In small buildings, it is usually possible to arrange the drains in such a way that the soil pipe enters the main drainage or other of its extremities, be that at the head or at the outlet of the drainage system. If, then, the air inlet shaft is provided at the other extreme end, the drains will be ventilated throughout. Where this is not practicable, and the main drain, or a branch drain, has to be carried to some appreciable distance beyond the soil pipe, a subsidiary ventilation shaft must be connected to the head of each such drain. Short branch drains need not, however, be taken into consideration, as the discharges through them are usually sufficient to displace their aerial contents and bring it under the influence of the air current in the main drain.

It is hardly necessary to point out that the effective, or unobstructed, area of ventilation pipes (both inlets and outlets) must at least equal the sectional area of the drain or drains upon which they are provided. It may, however, be pointed out that, to obtain efficient ventilation, the outlet shaft should not be more than 100 yards distant from the inlet by which it is served. Should this distance be exceeded, as in the case of a long drain, the drain should be subdivided into sections, by the insertion of disconnecting traps, and each of these provided with an inlet and an outlet at the least.

Steam Pipe Covering Test.

A TEST on an asbestos steam pipe cover supplied by Messrs. The Bell's Asbestos Company, Limited, was recently made at the National Physical Laboratory.

The test pipe was a 4 in. steel pipe, 4·47 in. external diameter and 14·34 ft in length, having a total radiating surface of 16·85 sq. ft.

The observations made were (1) weight of steam condensed, (2) temperature of steam, (3) temperature of air at two different places, (4) temperature of outside of cover.

From the steam temperature is found the pressure of the steam and the "latent heat." The weight of water collected multiplied by the "latent heat" gives the total loss in B.T.U. from the pipe. From this is substracted the total heat loss from the flanges and ends, the net loss from the pipe being thus obtained. This net loss divided by the latent heat gives the condensation in the test pipe alone in pounds.

Particulars of the Cover.

This cover was in flat sections about 3 ft. by 2 ft., which were wrapped round the pipe and laced with copper wire.

Mean thickness of cover = 1·53 in.
Total weight of cover = 28·25 lb.
= 2·0 lb. per foot run.

A test was also made with the bare pipe for comparison.

Table of Observations.

	Asbestos covered pipe.	Bare pipe.
Temperature of steam ...	393·4 deg. F.	392·7 deg. F.
Temperature of cover ...	103·6 ,,	—
Temperature of air ...	64·0 ,,	67·7 ,,
Steam condensed by air	6·245 lb.	30·52 lb.

CALCULATED RESULTS.

	Asbestos covered pipe.	Bare pipe.
Steam pressure (gauge) ...	215 lb. per sq. in.	213 lb. per sq. in.
"Latent heat"	837 B.T.U. per lb.	837 B.T.U. per lb.
Difference of temperature between steam and air	329·4° F.	325° F.
Total loss of heat per hour ...	5,225 B.T.U.	25 550 B.T.U.
Loss due to flanges and ends...	2,245 ,,	2,170 ,,
Net loss due to pipe	2,980 ,,	23,380 ,,
Condensation per hour from test pipe...	3·56 lb.	27·9 lb.
Ditto per square foot	·212 lb.	1·66 lb.
Loss per square foot per hour per degree difference of temperature...	54 B.T.U.	4.27 B.T.U.

From these figures the following table has been calculated, assuming an air temperature of 70 deg. Fah.:—

Pressure by gauge, lbs. per sq. in.	Loss in B.T.U. per hour per sq. ft. of 4 in. pipe.		Steam condensed per hour per sq. ft. of surface of 4 in. pipe in lbs	
	Asbestos covered.	Bare.	Asbestos covered.	Bare.
190	168·4	1,339	·200	1·59
200	170·6	1,357	·203	1·61
210	172·7	1,373	·206	1·64
200	174·6	1,389	·209	1·66

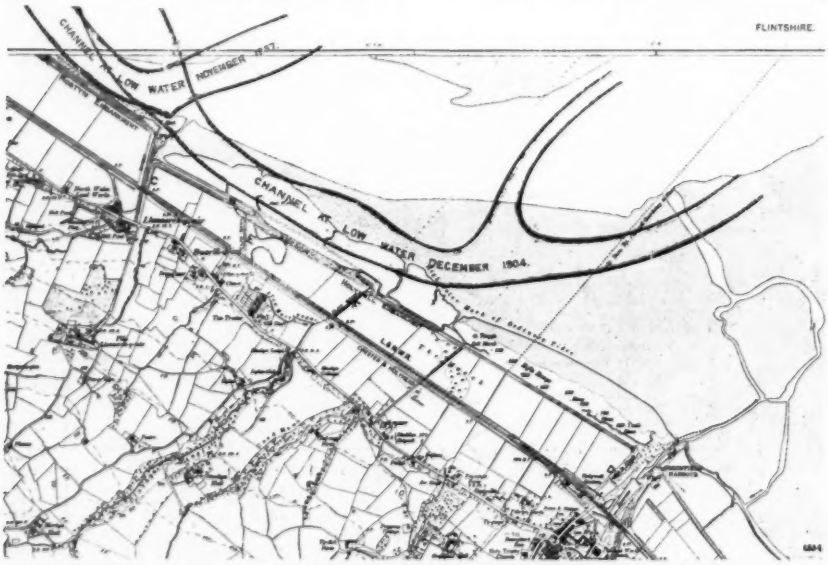
Saving due to cover equals 87 per cent. of total condensation

ENGINEERING PROGRESS

Chester and Holyhead Railway. River Dee Encroachment at Holywell.

At the time of the construction of the Chester and Holyhead Railway near to the banks of the River Dee at Holywell, an earth embankment or cop, previously constructed by landowners to reclaim a considerable area of land, prevented the spring tides of the River Dee from coming nearer he railway than 150 to 200 yards, and the main or navigable channel of the river at that time was about 1½ miles distant from the earth cop. Of recent years, however, the channel has come closer to the Flintshire shore, and it became necessary near Mostyn to protect the earth bank and marsh lands with large quantities of rough rubble stone, deposited in the first instance by the landowners, and subsequently, on their relinquishing the work, by the railway company, the effect of which at this particular place has been to prevent further encroachment.

The embankment is indicated by a letter *A* on the attached map, the course of the channel in 1887 being shown. In the spring of last year, however, the main channel, from natural causes, took a turn opposite the Holywell embankment indicated by the letter *B*. This embankment was entirely unprotected by stone or other material, and temporary measures were taken to prevent damage by depositing bags filled with sand and clay to allow sufficient time for the permanent protection of the railway embankment, in the hope that the channel would again recede and so save the expense of adopting more permanent measures to protect the sea wall. There were signs in the summer of 1903



MAP SHEWING THE CHANGE OF POSITION IN THE MAIN CHANNEL OF THE RIVER DEE AT HOLYWELL.

CROSS SECTION OF HOLYWELL EMBANKMENT.

that this was about to take place, but during some severe gales in the autumn of the same year, and the consequent overflowing of the salt marshes by the high tides, the effect of the waves on the earth bank was to cause a breach, and as the fields intervening between it and the railway were several feet below the level of the high spring tides, as shown on the sketch cross section, the embankment along the line, which is 7 to 8 ft. above field level, was threatened by the wash of the water. Steps were immediately taken to pitch the railway slope in a permanent manner with stone and concrete, and large quantities of slag, stone and other material were deposited in the breach, and for a considerable distance each side thereof, to protect the edge of the land, which for a depth of at least 60 ft. was known to consist only of sand and silt. Much of the stone was deposited on the surface of the field or marsh land, which formed a protective covering to the slope when the channel or tide water washed away the ground underneath. Up to the present time 70,000 tons have been deposited, the lines and sidings in connection with carrying out the work extending for over a length of 2 miles, but the face actually protected averages about ¾ mile. The stone in most places alongside the channel diversion is from 3 to 4 ft. thick. The work has been tested by several strong gales, but no damage of any consequence has been done. To prevent the tidal water covering so large an area of land as that extending from *C* to *D* on plan, two clay banks have since been constructed

AT WORK ON THE HOLYWELL EMBANKMENT.

about 4 ft. in height, one on either side of the breach, and have proved successful. They are indicated by the letters *E* and *F*, and confine the tidal waters within this area. At one time over 700 men were employed on this work, but the number has now been reduced to about 60.

Floating Docks.*

THE floating dock, although in common use, is less known in England than elsewhere, which can be ascribed to the fact that the rise and fall of tides on the British coasts naturally favours the excavated form of dock, whereas, in non-tidal waters, the floating dock is equally as common as the other.

The simplest form of floating dock consists of a hollow pontoon, forming the buoyant or lifting portion, with two hollow tide-walls on top of the same, forming the controlling portion of the system; to this the name of "Box" Dock has been applied. When built of iron, however, such docks required means of protection against rust and decay, and the self-docking principle was evolved. The first form of this consisted in constructing the Box Dock in such short sections that they could lift each other, and to this type the name of "Sectional" Dock has been given. Later, in order to avoid the use of the numerous small sections, a modification was introduced by which two sections of any length lifted a third section between them, by allowing it to rest on the projecting ends of their pontoons. Such "Sectional" Docks, however, presented no longitudinal rigidity whatever, and consequently another departure was made in which the pontoons only were built in sections, being bound together by continuous side-walls, and the self-docking operation consisted in removing any one pontoon from under the side-walls and lifting it on to the rest of the dock. This type is known as the "Sectional Pontoon" Dock. The longitudinal rigidity of this type, however, was not very great, and, having the problem set them of lifting both long and short vessels of equal displacement on the same dock, the author's firm introduced, in 1895, a new type which is now known as the "Havana" type. In this, the continuous side-walls are on each side instead of on top of the pontoons, thus extending downwards to the full depth of the same, and forming strong girders, to the sides of which the pontoons are bolted. The self-docking of this type is carried out by unbolting the desired pontoon from between the side-walls and docking it on the rest of the dock. Later still, when yet greater rigidity was required, the firm introduced a new form, known as the "Bolted Sectional" Dock, this being an ordinary sectional dock, but with the different sections rigidly bolted together. The self-docking of this type is effected by so designing the end sections with points or projections that these points can take under the square-ended central section and lift it, or, alternatively, enter between the walls of the same when an end section is being lifted.

Of the one-sided types of dock one is the "Depositing" Dock, in which the necessary stability is obtained by attaching the L-shaped dock to a floating outrigger by means of parallel hinged booms, the body or pontoon of the dock being built in the form of separate fingers. These fingers, which carry the ship, are floated in between similar fingers of pile work or masonry placed on the shore. The dock is allowed to sink, leaving the ship supported on this fixed staging, and the dock is then free to deal with other vessels. The other type, namely the "Off-shore" Dock, has the pontoon as a continuous structure, and stability is obtained by connecting the dock, by means of parallel booms, to columns fixed in the foreshore, the top boom being connected to a weighted cam which allows the dock to heel slightly athwart-ships, so that its horizontality can be maintained by regulating the valves. Lastly, a combination of the foregoing two types is mentioned, wherein the continuous pontoon is used in conjunction with a floating outrigger, on which are carried the dock's boilers and any small repairing shops and machinery required in connection with the dock.

The paper then passes on to the chief problems that confront the designer of a floating dock. The most important of these is the determination of the longitudinal strength required when carrying a short, heavy ship on a long dock; and closely analogous to this is also the determination of the strains to which a dock is subjected in a sea-way. The transverse strains due to the ship resting centrally on the dock are also treated of, and different types of internal bracing are discussed, especially the design of that portion of the dock which comes directly under the ship's keel. Lastly, the local

* Lyonel E. Clark, M.Inst.C.E., Procs. Inst. Civil Engrs., Jan., 1905.

strains on the dock's structure due to water-pressure when submerged, and the working-stresses allowable under such conditions, are referred to.

The stability of a floating dock next engages the author's attention, and the ordinary method and rules employed are given, for the stability of a ship is governed by different conditions from that of a dock. In the former, the shape of the water-planes varies but slightly, but the angle of heel may be very great; whereas in the latter the shape of the water-planes is always varying, but the angle of heel permissible is so small that it can be virtually disregarded in its effects. The stability of a dock is, therefore, best expressed by means of a curve giving the metacentric heights at all states of immersion, from the time when it is sunk ready to receive a ship until the vessel is lifted, and the pontoon deck is above water. The method of calculating the stability of the one-sided types is also treated of, showing how, in the case of the depositing dock, it is the floating outrigger which has to provide the righting moments, whilst in that of the off shore dock, the weights on the regulating cams have to be arranged to give the required control.

The paper next proceeds to discuss the advantages and disadvantages of the floating dock as compared with the excavated dock. First, it is pointed out that the time required for constructing a floating dock is much less than that needed for the excavated dock, and instances are given of large docks having been completely designed and built in well under a year. The advantage of the mobility of the floating dock is then discussed, both from the point of view that this allows of its being built in the cheapest and most suitable yard and then towed to its destination, and also that in the case of alterations to its site, or development of the port where it is placed, it is not tied to such site or port, but may be bodily moved to any more suitable place. The advantage of mobility from a strategical point of view is also shown, and it is pointed out how such a dock would be useful in connection with any existing arsenals, which are naturally always placed at some distance from the sea, for it could be sent down the channel to pick up and catch "lame ducks" before they attempted the narrow passage leading to the arsenal. The author mentions that it has indeed been proposed that a floating dock should accompany a fleet into action, ready to pick up wounded vessels after an engagement, but in his opinion this is not yet a practical scheme, the difficulties of propelling such a dock even at ordinary cruising-speeds being insurmountable. At the same time, he strongly advocates the use by all naval powers of a floating dock, towed by a vessel containing ordinary ship-repairing tools, which could at any time be easily transferred to any base that the fleet may have seized, or could provide or supplement the docking accommodation in those home ports where the same did not exist or was of insufficient capacity. The drawback to the extensive use of such a dock would naturally be the depth of water required at its moorings, but it is pointed out that the maximum amount of excavation required for the berth of a floating dock would never be more than that required for the excavated dock, with the advantage that whereas in the latter case the excavation would have to be made entirely in the dry, in the former it would merely be the removal of material by ordinary dredgers. On the other hand, the floating dock possesses many advantages in the choice of site, since it can be placed end-on with the stream, thus facilitating the entrance of vessels; and it does not require its entrance to be placed, like that of most graving-docks, more or less at right angles to the stream. Again, in rivers which are subject to a strong freshet, the floating dock is equally available either at high or low water, whereas a stone graving-dock would either have to be built very much deeper than required, or else would be submerged in times of flood. In connection with this, the author discusses the point whether a vessel on a floating dock is not much better placed for purposes of repairing or painting than in the bottom of an excavated dock, and points out how open to light and air are vessels on the former. He also claims that this openness of the floating dock has other advantages in that it allows them to deal with vessels of much greater length than the dock itself, and instances of this facility are adduced; whilst the one-sided docks have an equal advantage as regards beam of vessels lifted. It is admitted that floating docks have their limitations, represented by the amount of their lifting power, but at the same time it is argued that though they may not be able to lift a vessel entirely, they can frequently lift it enough to enable the required repairs to be effected.

The first cost of floating docks is dealt with, and in order that an idea of their cost may be obtained, a list of the actual

hull weights of several docks of different types are given.

The cost of working is also dealt with, and it is pointed out that the floating dock has a great advantage in respect of the cost of coal and oil, as the power required to lift a ship is much less than that required for a graving-dock of similar capacity. Instances are given where it costs, on the average, less than 18s. to lift vessels displacing 3,000 tons.

The cost of maintenance of a floating dock is gone into in some detail, and in the Appendix many instances of the actual amounts expended on repair and upkeep are given, based on the results of a number of years; from these it is found that the average cost is a little more than 1 per cent. per annum of the first cost of the dock.

Some further statistics are given as to the useful life of a floating dock, and iron docks which have now been at work for over 40 years are mentioned: from which the author concludes that the useful life of a floating dock may be fairly taken as at least 50 years. He points out that a life of this duration requires only a sinking-fund equal to 1 per cent. per annum on the first cost of dock invested at 2½ per cent.

Multiple Effect Evaporation.*

ORDINARY multiple effect evaporators consist of two or more vertical cylindrical vessels partaking of the character of surface condensers. Steam, either in the form of exhaust from the engines, or direct from boilers, is usually, though not necessarily, the source of heat by which the evaporation is brought about. The steam thus supplied is taken to the first of the vessels and there surrounds tubes containing the liquor to be evaporated. The pressure inside the tubes is kept lower than the pressure of the steam supplied to the casing around the tubes, consequently the boiling temperature of the liquor inside the tubes is lower than the temperature of the saturated steam outside, with the result that the steam will be condensed to water, which, however, will still be at a higher temperature than the liquor and vapour in the tubes.

The heat thus given up will practically be the latent heat of the steam, and each pound of steam condensed will evaporate approximately 1 lb. of the water in the tubes, thus generating steam in the tubes. This steam is then conveyed by means of a suitable pipe to the calandria of the second vessel, which also contains tubes through which the liquor to be evaporated passes.

The pressures in the second vessel and in the tubes are lower than in the first vessel and tubes respectively, hence the steam generated in the tubes of the first vessel now surrounds tubes containing a liquor at a lower temperature; it is therefore condensed, and in condensing evaporates approximatety another pound of water. By this means, each pound of steam supplied to the apparatus has now evaporated approximately 2 lb. of water. If, then, the apparatus has three vessels or effects, and the pressure in the third is kept lower than the pressure in the second vessel, the steam generated in this latter can be taken to the third vessel and used to evaporate another pound of water there. This system can be carried on to 4, 5 or 6 effects, or, in fact, to as many effects as the temperature limits will allow.

Fig. 1 illustrates in diagrammatic form a common arrangement of triple effect evaporator as used for the concentration of many kinds of solutions. A_1, A_2 and A_3 are the shells of the three effects. B_1, B_2 and B_3 are the calandrias or portions containing the heating tubes. C_1, C_2 and C_3 are the vapour pipes. D_1, D_2, D_3 and D_4 are the juice or liquor pipes.

The steam used for effecting the desired evaporation enters at the calandria B_1 of the first vessel through the opening shown on the illustration and circulates round the tubes of what is practically a short surface condenser. The liquor entering the first vessel through pipe D_1 is usually hot, and assuming that it is nearly at its boiling temperature it will be seen that the condensation of 1 lb. of steam on the outside of the tubes will cause the evaporation of nearly 1 lb. of water in the tubes, the difference of pressure on the two sides of the tubes being, as already stated, sufficient to give the temperature difference necessary to effect the transmission of heat through the material of the tube. The steam so generated rises to the top of the first vessel and is conveyed by means of the pipe C_1 to the calandria of the second vessel, where, owing to the pressure on the liquor, and consequently the boiling temperature, being lower than the pressure and temperature of the steam obtained

* Chas. Day, Procs. Manchester Assocn. Engrs., Jan., 1905.

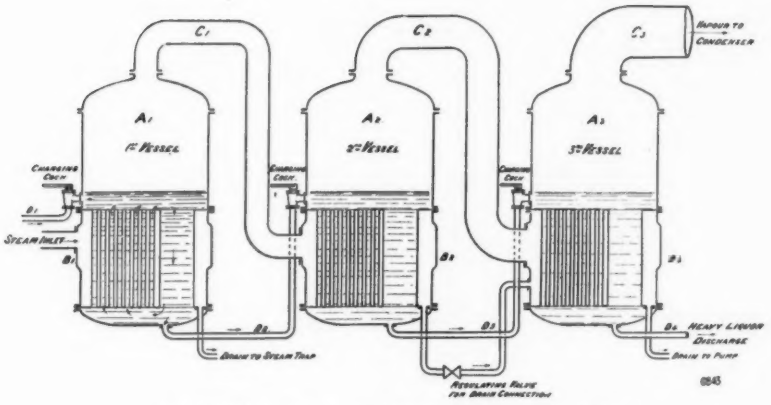


FIG. I.—DIAGRAM OF AN ORDINARY TRIFLE EFFECT EVAPORATOR.

from the first effect, this steam evaporates a portion of the liquor in the second vessel, and in its turn is condensed.

The steam from the second vessel is then similarly used in the third; the steam generated in this latter afterwards passing to the condensing plant.

As just stated, the liquor or juice to be evaporated or concentrated is fed into the first vessel of the apparatus by means of the pipe D1, and should enter at as high a temperature as possible. From the first vessel it passes to the second and thence to the third, and as the pressure in each succeeding vessel is lower than in the preceding one, no pump is required beyond the pump necessary to force it into the first vessel (or by having the supply tank at a suitable level), but a regulating cock, or other device, is placed between each vessel so that the rate of flow through the apparatus and the level of liquor in each vessel can be regulated. The pressure in the last vessel is almost always below that of the atmosphere, consequently a pump has to be provided to withdraw the final liquid.

The water drained from the first calandria is usually returned to the boiler, but that formed in the second and third calandrias is not, as it may have absorbed injurious gases given off by the evaporation of the liquor.

Where the object of evaporation is to concentrate the liquor, such concentration takes place as the liquor passes along the evaporator, and the rate of flow is regulated so as to give the required density to the liquor when it is withdrawn from the apparatus.

In the case of water distillation, the density of the remaining liquid or brine is carried close up to the point at which, owing to saturation, the salts would begin to be precipitated.

In dealing with the concentration of certain liquors, it is desirable that the highest density should be accompanied by the highest temperature, as owing to the increased fluidity at higher temperatures the concentration can then sometimes be carried to a greater degree. Under such circumstances the liquor, instead of entering the first vessel and finishing at the third, may have its passage through the machine reversed; this, however, necessitates pumps to convey it from vessel to vessel owing to the pressure rising in the direction of the flow instead of falling.

In the design of evaporators of the type under consideration, one important point is the rate of heat transmission through metallic surfaces. This is a subject which, though much experimented upon, is still very vague, and is one worthy of further investigation. The experiments which have been made with surface condensers and with evaporator tubes of various diameters have given very contradictory results.

Newton's law that the transmission of heat is directly proportional to the difference of temperature is no longer accepted as true.

The most complete series of experiments of which the writer has information are those of Mr. G. A. Hagemann, of Copen-

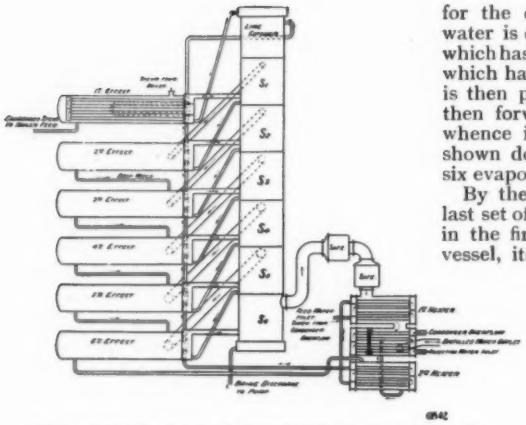


FIG 2.—DIAGRAM OF A SIX EFFECT FRESH WATER EVAPORATOR.

hagen. An extract of these can be found in the "Proceedings of the Institution of Civil Engineers," Vol. 77. These experiments included determinations of the rate of heat transmission through brass tubes for different ranges of temperature and for different rates of flow of liquor through the tubes, steam being on the outside of the tubes.

These experiments were made with vertical tubes and may not apply equally to horizontal ones. The principal results which bear on the present question are that there is an increase in the rate of evaporation per sq. ft. by rapid circulation of the liquid in the tube, and doubtless this applies not only to evaporators and condenser, but also to boilers.

Further, that the rate of transmission per degree of temperature difference is greatest when the temperature difference ranges from 15 deg. F. with a low speed of flow to 40 deg. when the speed of flow is 5·4 ft. per sec.; and, finally, the rate of transmission is much higher when heat is transmitted to a boiling liquid than to one not boiling.

Other experimenters have found that the heat transmission per sq. ft. is 3 to 4 times as rapid when the liquid is boiling than when otherwise, which fact may explain the greatly improved output from boilers when very hot feed-water is supplied to them. Possibly the advantage of live steam feed-heaters on board ship may be largely due to this cause.

Fig. 2 is a diagrammatic drawing of a six-effect Yaryan evaporator. When used for the distillation of water, the impure water is drawn from the circulating water which has passed through the condenser and which has thus been somewhat heated. It is then pumped through the first heater, then forward through the second heater, whence it passes through heating tubes, shown dotted on diagram, in each of the six evaporating vessels or effects.

By the time it has passed through the last set of heating tubes, which is contained in the first, or high temperature, effect or vessel, its temperature will not be much below the temperature of the steam supplied to that effect. At this point it may be taken to a lime catcher, containing a steam coil which brings the water to that temperature at which most of the lime and similar salts are readily precipitated; suitable re-agents may be added to assist precipitation. Before leaving this lime catcher the water is filtered; it then passes to the evaporating tubes of the first effect. The shell of this vessel or effect receives steam from the boiler at a pressure of about 40 lb. per sq. in. In many cases a higher pressure and a greater number of effects may be adopted where the liquor is such that treatment at a high temperature is not likely to be injurious, but machines are seldom made with more than six effects.

The water formed by the condensation of steam supplied to the first effect is usually returned direct to the boiler, thus the boiler is fed with pure distilled water at a high temperature, consequently a high evaporation per pound of coal should result and be well maintained. The steam formed in the tubes of the first effect, together with the water, pass to the separator S1, where the steam separates from the water and is led to the shell of the second effect, whilst the water passes into the tubes of this effect. The pressure in the shell of this effect practically corresponds with the pressure in the tubes of the first effect, but the pressure in the tubes of the second effect is several pounds lower, hence as the water entering the tubes is at the higher temperature of the previous effect there is immediate and spontaneous evaporation of some of the water, and this causes a lowering of the temperature of the remainder, which reduction of temperature permits of heat being transmitted through the tubes from the steam on the other side causing evaporation of a further quantity of water and the condensation of the steam

outside of the tubes. Again the mixed water and steam pass to the separator S2, and the separated steam is then led to the shell of the next effect, and the water to its tubes, but as the water produced by the condensation of the steam supplied to the shell of the second effect is not wanted for boiler feeding, it is drained into the shell of the third effect as shown, and there imparts some of its heat to the water in the tubes. Spontaneous evaporation also takes place here, owing to the water entering a vessel in which the boiling temperature of water is lower than the temperature of the incoming water.

This cycle of operations is repeated in succeeding effects until the last one is reached, which, in the example chosen, is the sixth effect. From here the water drained from the second, third, fourth and fifth effects, together with the water of condensation formed on its own tubes, is drained to the second heater, whence it passes to the condenser. The steam from the last separator, S6, passes through the safes to the first heater, where some of it is condensed, the final condensation taking place in the surface condenser shown, where not only does this condensation take place, but the water so formed is, along with the water drawn from the previous shells, finally cooled by the circulating water in condenser.

This final action serves the double purpose of raising the temperature of the water which is to be used to feed the machine and of cooling the distilled water which has been produced in the machine. The residual water—or concentrated brine if treating sea-water—from the sixth separator is pumped out by a separate pump, called a brine pump, and is usually discharged to waste if the primary object of the plant is to produce distilled water, though this brine may be treated further in open pans and salt obtained from it.

From this description it will be seen that this form of evaporator secures the high rate of flow through the tubes which Mr. Hagemann's experiments show to be so desirable, and, from figures given later, it will also be seen that the temperature differences correspond very closely to those, which, according to Mr. Hagemann's curves, give the best results.

If, now, a six effect Yaryan evaporator be supplied with steam at a pressure of 56 lb. per sq. in. absolute (temperature 288 deg. F.) and the condenser vacuum be 28 in. or 1 lb. absolute, then the total range of temperature would be 288 – 102 or 186 deg. F., which, if divided equally between the six vessels, would be 31 deg. F. per effect. Though this would appear to be the most favourable division, experience has shown that a rather larger temperature difference is advantageous in the last, or last two effects.

With evaporators of the type shown in Fig. 1, and without combined heaters, the variation of temperature difference would be greater than with the type shown in Fig. 2, where heaters are embodied with each effect. And it must be remembered that as each effect forms the condenser for the previous, the amount of work done by the machine is to a large extent measured by that effect which has the lowest condensing capacity.

CALCULATION OF OUTPUT FROM A SIX EFFECT EVAPORATOR USED AS A WATER DISTILLER.

Assume that the pressures are regulated as per preceding list, and water leaves each set of heater tubes within 10 deg. F. of temperature and surrounding steam, also that 1 lb. of live steam is supplied to the shell of first effect at an absolute pressure of 56 lb. per sq. in., and that 5·5 lb. of water are fed into apparatus.

To enable the figures to be followed more readily I have taken the specific heat of the water as being constant, the error arising from this being less than 1 per cent.

FIRST EFFECT.

	British Thermal units.
Shell.—Heat received = 1 × 1,201 (thermal units in 1 lb. of steam) .. =	1,201
Heat rejected in drain water 1 × 288 =	290
∴ Heat used	911
Tubes.—Heat in entering water which is 10 deg. below temperature of steam in second effect, and therefore 10 deg. also below the boiling temperature in the tubes it is entering) = 5·5 × 252 .. =	1,386
Heat used in raising temperature of water in evaporating tubes 10 deg. = 5·5 × 10 .. =	55
Do. in raising temperature of water in heater tubes = 5·5 × 26 .. .. =	143
Do. in evaporation = 911 – 55 – 143 .. .. =	713
Latent heat of steam at 36 lb. pressure .. .. .. =	930
∴ Evaporation .. = $\frac{713}{930}$ = 0·766 lb.	

0·766 lb. of steam pass to shell of second

effect, and 5·5−0·766 or 4·734 lb. of water to its tubes.

SECOND EFFECT.

Shell.—Heat received .. =0·766×1,193
,, rejected .. =0·766× 262
,, available .. =0·766× 931=713

In the tubes of this and succeeding effects the water enters at a temperature above the boiling temperature for the pressure in the tubes, hence there is spontaneous evaporation of a sufficient amount of the water to cause the necessary lowering of the temperature of the remainder. This evaporation may be calculated thus:—

Total heat in water before spontaneous evaporation = total heat in water and steam afterwards.

Let X = amount of water thus evaporated,
then $4{\cdot}734\times 262=(X\times 1{,}185)+(4{\cdot}734-X)\ 236$
$1{,}240=1{,}185\ X+1{,}117-236\ X$
$X=0{\cdot}13$ lb. leaving 4·6 lb. of water (4·734−0·13)
water in heater tubes of second effect is raised from 226 deg. to 252 deg.

∴ heat used = 26 × 5·5 = 143 units.

Heat available for further evaporation = 713 − 143 = 570 units,

$$\therefore \text{evaporation} = \frac{570}{948} = 0{\cdot}6 \text{ lb.}$$

steam passing to shell of third effect = 0·6 + 0·13 = 0·73 lb. Drain water passing to shell of third effect = 0·766 lb. at 262 deg. F. Feed water passing into tubes of third effect = 4·734 − 0·73 = 4·0 lb. at 236 deg. F.

THIRD EFFECT.

Shell.—Heat received from second effect—
Steam .. 0·73×1,185= 865
Drain water 0·766× 262= 200
1,065
Heat rejected 1·496× 236= 353
Difference .. .. .. = 712 units transmitted through tubes.

Heat absorbed at heater tubes, 5·5 × 26 .. = 143

Leaving .. .. .. 569 units for evaporation

Evaporator Tubes.—Heat received in water from second effect—
4·0×236=944
Do. through the tubes=569

∴ Total heat in 4·0 lb. mixed steam and water .. .. .. =1,513
Let X = weight of steam
then $(X\times 1{,}177)+(4{\cdot}0-X)\ 210=1{,}513$
$X=0{\cdot}7$ lb.

FOURTH EFFECT.

Shell.—Heat received from third effect—
Steam .. 0·7 ×1,177= 824
Water .. 1·496× 236= 353
1,177
Heat rejected 2·196× 210= 461
Difference .. .. .. = 716
Heat absorbed at heater 5·5×28 .. .. .. = 154

Leaving .. .. .. 562 units for evaporation

Evaporator Tubes.—Heat received in water from third effect 3·3×210 .. .. =693
Do. through tubes .. .. =562

∴ Total heat in 3·3 lb. of water and steam .. .. =1,255
$(X\times 1{,}169)+(3{\cdot}3-X)\ 182=1{,}255$
$X=0{\cdot}663$ lb.

FIFTH EFFECT.

Shell.—Heat received from fourth effect—
Steam .. ..0·663×1,169= 775
Water .. ..2·196× 210= 461
1,236
Heat rejected ..2·859× 182= 520
Difference 716
Heat absorbed at heater .. 5·5× 30= 165

Leaving .. .. 551 units for evaporation

Evaporator Tubes.—Heat received in water from fourth effect=
2·637×182 .. .. = 480
Do. through tubes .. .. = 551

Total heat in 2·637 lb. of water and steam .. .. .. =1,031
$(X\times 1{,}160)+(2{\cdot}637-X)\ 152=1{,}031$
$X=0{\cdot}62$ lb.

SIXTH EFFECT.

Shell.—Heat received from fifth effect—
Steam .. .. 0·62×1,162= 720
Water .. ..2·859× 182= 520
1,240
Heat rejected ..3·479× 152= 528
Difference 712
Heat absorbed at heater .. 5·5× 30= 165

Leaving .. .. 547 units for evaporation

(External heaters will readily raise the water to within 30 deg. of temperature of shell of the sixth effect.)

Evaporator Tubes.—Heat received in water from fifth effect $2{\cdot}017 \times 152$ .. .. = 306
Do. through tubes .. .. = 547

Total heat in 2,017 lb. of steam and water = 853

$$(X \times 1{,}145) + (2{\cdot}017 - X)\ 102 = 853$$
$$X = 0{\cdot}62 \text{ lb.}$$

Total production of distilled water is the sum of the amounts produced in the various effects, and = 4·1 lb. per lb. of steam used. As 5·5 lb. of water are pumped into the apparatus the difference of 1·4 lb. is discharged brine.

Remembering that the boiler is fed with pure water at a high temperature, an evaporation of 12 lb. of water per lb. of coal is quite practicable; the production of distilled water per lb. of coal would then be $12 \times 4{\cdot}1$ or 49·2 lb. Allowing 10 per cent. for radiation and other losses we get an evaporation per lb. of coal of 44·3 lb., with about 25½ per cent. of the entering water discharged as brine. If the character of the salts would permit of this percentage being lowered the efficiency would be improved.

For comparison with these calculated figures the results of a test of a six effect machine at Mombassa, East Africa, are given below:—

Yield of gained water per 24 hours ..	66·6 tons
Yield of gained water per lb. of fuel consumed	44 lb.
Class of coal	Welsh

Evaporators of this type are very widely used for the concentration of soda solutions, meat extracts, glue and gelatine solutions, etc.

The various pumps connected with the apparatus discharge their exhaust steam into the first effect, and consequently work against a back pressure of about 40 lb. above the atmosphere. To permit of their working under these conditions the boiler pressure is usually 80 to 100 lb., and the surplus steam required by the evaporator beyond that obtained from the pump exhausts, passes through a reducing valve. Where evaporators are used for concentrating trade solutions the general practice is to have only two or three effects so that the pressure in the first effect does not need to be over 5 lb. per sq. in. above the atmosphere, thus enabling the evaporation to be done by exhaust steam from the various engines. This is a more economical practice than working engines condensing and supplying live steam to the evaporator.

Fuel Economy in Steam Power Plant.*

THE chain grate stoker is perfect as a self-cleaning contrivance, but admits excessive air. Hence the need of choking boxes, as employed by Mr. E. B. Coxe, Fig. 6.

These difficulties with travelling grates are reponsible for the sprinkling form of stoker, which, when in good order, keeps the grate evenly covered, as the coal tends to fill the hollow places. But the winnowing action of the draught carries off the dust to become a public nuisance. Such stokers require initially providing for, in the design of a chimney with a settling chamber to gather the dust.

* Continued from p. 633, by W. H. Booth and J. B. Kershaw.

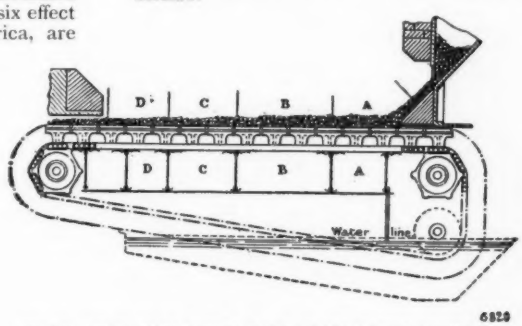


FIG. 6.—CHAIN GRATE STOKER, WITH AIR-REGULATING CHAMBERS BELOW.

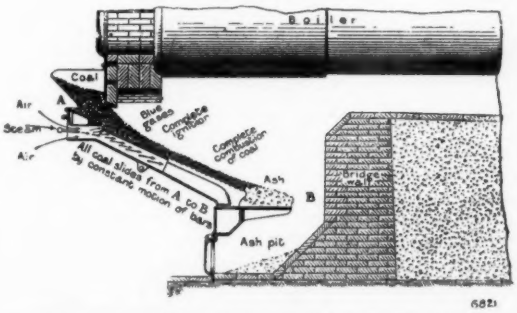


FIG. 7.—INCLINED GRATE WITH SHAKING AND GRAVITY EFFECTS.

The economy of mechanical stokers lies in their ability to raise sufficient steam with cheaper coal than hand-firing demands, and in the reduction of the stoking staff. But mechanical stokers will not be an economy unless their hoppers are filled mechanically, and they ought to be in charge of a skilled mechanic to look to upkeep and maintenance, and not to be expected to run with unskilled attention.

The ideal mechanical stoker is of the inclined grate type, Fig. 7, in which the inevitable thinning of the fire of the coking furnace is made good by the aid of a moving grate assisted by gravity. In this type, only possible in its full extent with external furnaces, the fuel is helped to fill gaps and close the lower end of the fire by gravity, and at the foot of the inclined grate is some arrangement which enables ash and dirt to be removed.

Rocking grates which profess to cut out the ash and clinker from the under side of the fuel bed are of doubtful use, for clinker is tough and adhesive when hot. It becomes brittle only when chilled, and users of such bars should be prepared at least to have each half of the grate workable independently. The system may then be used to clean a grate quickly, after the clinker has been chilled by removal of the fire to the other half of the grate.

Smoke Prevention.—This can often be managed by excessive air admission, for the reason probably that though air in excess has a chilling effect, its ample provision enables all the gases to burn before they have lost much temperature. But smoke cannot be prevented with economy unless sound conditions are present as already detailed, and the crux of the whole matter is summed up by saying that a maximum percentage of CO_2 must be present in the furnace gases.

Could the furnace products be rejected at atmospheric temperature, an excess of air would be of no account. But the heating surfaces commercially available render it impossible to cool rejected gases below, say, 400 deg. F., whatever the supply of air, and obviously the loss of heat is greater where air is used in excess. This point is emphasised because there is frequently a serious confusion of thought in relation to heat and temperature and the weight of the gases possessed of such heat or temperature. Cold flue gases, unless of small weight per unit of fuel, do not represent economy, but excess of air. Some people think otherwise.

Steam.

Steam loses heat from the moment it leaves the boiler. The surfaces which con tain it must therefore be of minimum area This involves pipes of minimum length and is one of the various reasons for avoiding ring mains, the fancied need for which is obviated by using good materials well put together for steam-piping. Short pipes make it possible to carry a given weight of steam with less drop of pressure, or otherwise to carry the same steam at the same pressure fall through smaller pipes.

The loss of heat through pipes varies with the head of temperature. The weight of steam that will flow through a pipe varies with the pressure absolute very nearly. The pressure of steam rises faster than the temperature, and high-pressure steam (realised to be economical) will lose less heat than the low-pressure steam, if the pipes are as much smaller as they should be for the high pressure. It is a mistake to employ steam-pipes so large that there shall be no appreciable fall of pressure. Some fall, 3 to 5 lb., per square inch may be allowed in long pipes, for there is a point where the saving due to high pressure will be lost by the extra radiation from the larger pipes.

Wet steam travels with more friction than dry steam. Superheated steam, despite its greater head of temperature, loses heat less rapidly by contact than does wet steam; it flows with less friction and loses less at joints. Less of it is also required, and pipes may be smaller.

There is no thermo-dynamic gain from superheat. Steam leaves the boiler at boiler temperature; it starts expanding at boiler temperature. The work done on the piston during admission comes directly from the fire, or is done by expansion of saturated steam in the boiler. The superheater is merely an incident in the steam pipe. The sole function of superheat is to ensure that steam, saturated with heat, and at maximum density per cubic foot for its pressure, shall be present in the cylinder to work expansively when steam is cut off from the boiler. Superheat is thus intended to heat the cylinder as hot as the boiler, and, by avoiding the presence of water in the cylinder, to minimise the exchanges of heat between the cylinder metal and the steam. Superheated steam supplies heat directly to the cooled surfaces which require it. The jacket, on the other hand, endeavours to maintain the outside of the working liner of the cylinder as hot as the boiler, and, while it may do some good in certain cases, it is always liable to do little else than evaporate water of condensation during the exhaust period.

The object of superheat is to supply saturated steam to fill the cylinder at the time of cut off.

Superheated steam is still often erroneously claimed to owe its superiority to the fact that less of it will fill a given space at a given pressure than is the case with saturated steam. This argument ignores the rapid drop of pressure which occurs when superheated steam expands. It ignores the fact that in a given bulk there is less heat and therefore less capacity for doing work. Therefore, while superheat is essential to economy, it is so only because it is the one means we possess of filling a cylinder with dry saturated steam.

To produce superheated steam has proved more difficult than might be anticipated, owing to the variable conditions of the furnace. To prevent superheater tubes burning away, steam is often made to rush through them at a high frictional velocity, whereby, its pressure being reduced 12, 15 and even 25 lb., much of the gain of superheating is sacrificed. In separately fired superheaters no tube will stand a temperature above, say, 1,400 deg. F. Few will stand more than 1,000 deg. to 1,200 deg. F. But a furnace worked with any regard for fuel economy has a temperature of waste gases of 2,500 deg. or 3,000 deg. F. All separately fired superheaters that do not possess a system of water control and temperature reduction, are made safe against the high furnace temperature by an enormous inlet of cold air through the grate or door, or through special air openings. As the superheater must inevitably reject its gases at, say, 700 deg. F., the surplus air is all rejected at that high temperature, and a large proportion of the advantage of superheat is lost. The separately fired superheater should abstract the surplus furnace heat in a rational manner, and this is best done by means of a shield of water between the furnace and the superheater. The advantage of the water protection shield in advance of the superheater tubes is that the feed-water for all the boilers of the set may be passed through the tubes and raised to the boiler temperature. The advantages of thermal storage are thus secured, for these are chiefly confined to the high rate of evaporation at which a boiler can be forced when fed with fully heated feed-water. Not only is priming reduced or prevented, but the whole working of the boiler is rendered more efficient.

To secure superheat economically, it is first necessary that the steam way through the superheater tubes should have an area equivalent to 25 to 50 per cent. in excess of the boiler steam-pipe. The ordinary small tube superheater, if given so much equivalent area, would not then cause the serious loss of pressure it now causes, but it would burn away more rapidly than it now does. In Germany, where, probably, small tube superheaters have a larger allowance of area, this burning out does occur rapidly, but it is said to pay to burn out tubes rather than to sacrifice so much pressure. There is no need to do either where water control of superheat is adopted, as proved by six years of steady work without deterioration. But a first-class water-controlled superheater, though it may last indefinitely, will cost double or treble as much as an ordinary uncontrolled superheater. In return for this, it will supply feed through the water control pipes at full boiler temperature, thus increasing the efficiency of the boiler considerably as well as the output.

In the manufacture of steam fit to be used in an engine, economy demands its production in distinct stages. The water, duly purified, is first raised to the temperature of condensation by the exhaust steam. This may be, say, 100 deg. F. It is next raised to a temperature of, say, 250 deg., 300 deg. or upwards, by means of the residual heat of the waste gases. If still below boiler temperature, the feed-water may be raised to that temperature by the water control apparatus of the superheater, and, in separately fired superheaters, by the water screen which protects the superheater pipes from too direct fire action. The boiler then comes into action and adds heat to the feed-water. All this heat ought to become latent. None of it ought to go towards raising feed temperature. Indeed, in the absence of the last-named stage of feed heating, a live steam heater should form this stage.

The boiler should produce steam which contains the maximum possible amount of heat per cubic foot, and is capable of performing work in the smallest possible cylinder. Unfortunately for economy, cylinders are made of material which exchanges heat with the steam, particularly if wet, and, despite all precautions, steam enters the cylinder loaded with water and cannot lose heat without liquefaction taking place. If superheated, its water contents are evaporated and its volume is increased. It can travel faster because its molecular kinetic energy is greater. It loses nothing at drains, and though it loses temperature it does not become wet so long as any superheat continues. It furnishes heat to the interior walls of the cylinder, and re-

duces those exchanges of heat which increase steam consumption by 20 to 25 per cent. Little or no superheat need remain at the point of cut-off, and there is then contained in the cylinder the greatest amount of heat possible at the given pressure. For the first cylinder of a compound engine steam should be superheated. The superheating of the steam between the cylinders is a matter of dispute. It ought to be economical, and, if it fails to be so, the cause is perhaps connected with the absence of drainage of the receiver. Engineers who have intermediate receivers capable of reheating, would perform a service if they would make commercial tests under the two conditions during a series of alternate weeks.

Superheating should therefore be considered as one of the final stages of dry steam production, the actual final stage being the cooling of the steam to saturation temperature, by means of the heat absorptive effect of the cylinder walls. Superheating is necessary to economy, because cylinders are not adiabatic. With superheated steam, cylinders are nearer to adiabatic conditions.

The economy from a given expenditure upon superheaters is to be found by suitably equating first cost charges, cost of stoppages to renew tubes, and maintenance generally with the economy of fuel that superheat will secure. There are only two classes of superheaters, the cheap apparatus without control, and the apparatus with water control of which class there is only one representative. Comparison would be therefore out of place by the authors.

The Waste Gases.

The temperature and chemical composition of the waste passing from every large boiler-plant ought to be regularly ascertained; the work being carried out by a man specially trained in technical gas analysis. The absence of smoke is no guarantee that combustion is being carried out in an economical manner, and only by constant testing of the exit gases can one be certain that the fuel is being burnt, without undue excess of air. The significance of air excess becomes manifest when one considers the following figures:—

With gases containing only 4 per cent. of CO_2 and a chimney temperature of 400 deg. F., 4,380 B.Th. units are lost for every pound of fuel burnt, *i.e.*, 32·4 per cent. of the total heat value of the fuel. It may be objected that this percentage of CO_2 is much lower than that present in the flue gases of Electricity Works; but the authors believe that this percentage is not exceeded in many works, where no special attention has yet been given to this question, and where no CO_2 testing apparatus has yet been installed.

In nearly every case where automatic or other CO_2 testing apparatus has been purchased and used, the authors know that all the earlier tests have been under 5 per cent. of CO_2, proving that under the every-day conditions of work obtaining in these plants, unduly large volumes of air were being admitted.

Where no economiser is installed, the loss of heating power is even greater, for the gases then pass to the chimneys at a temperature of from 600 deg. to 700 deg. F., and the heat losses rise to 6,570 and 7,665 B.Th. units, or to between 48 and 56 per cent. of the total heat value of the fuel.

Taking now the case where the boiler plant is under scientific control, and by constant testing the percentage of CO_2 in the exit gases has been raised to 12 per cent., the loss of heat with chimney gases at 400 deg. F. is reduced to 1,540 B.Th. units, or to 11·4 per cent. of the total heat value of the fuel.

In the one case, only between 44 and 68 per cent. of the heat can possibly be utilised; while in the other, 88·5 per cent. of the thermal value of the fuel may be converted into useful work—either in the boilers or in the feed-water apparatus. Engineers would therefore be wise to give most careful attention to this question of excess air supply to the boiler-furnaces, and to make proper provision for the constant sampling and testing of the exit gases.

The authors then proceed to a few general remarks on the subject of sampling and testing the exit gases.

Draught, etc.

A good draught is only an aid to economy when other conditions are good. Too good a draught must not be employed with a thin fire, for it will cause too large an influx of air. Fuel of a large size will stand a powerful draught, but also demands a thick fire. With a good draught it may occur that the closing of the damper will not only check the rate of combustion of the fuel, but will cause smoke by reducing the indraught of air through the door grids. Boilers are thus best partly regulated by dampers which close the ash-pits, rather than altogether by dampers in the flues. The ash-pit damper properly applied and used will prove an aid to economy.

The production of a chimney draught with a temperature of waste gas, say 300

deg. F. above atmospheric temperature, points to a consumption of heat about one-ninth of the total heat produced in the furnace. This fact points to the minimum air supply, which implies maximum furnace temperature and best efficiency of heating surface. Under normal conditions, however, from 20 to 30 per cent. of the total heat of coal goes up the chimney. It is claimed that a fan draught can be produced with about 1 per cent. of the total engine power, and that the use of a fan must therefore effect a great fuel saving. A fan will not save fuel unless it enables this to be burned more efficiently as above. A fan draught will give economy if, by its aid, a flue feed-water heater can be installed to reduce the excessive temperature of the flue gases. To use full effect feed-heaters, a high and expensive chimney is needed. Fan draught must therefore be considered in the light of enabling an economy in chimney construction to be effected, and full use made of feed-heating apparatus. It is also useful as enabling boilers to be forced to rapid steam production, and presents itself as a safeguard against sudden load in lighting stations and as a means of surmounting the load peak without excessive boiler plant. Fan draught is thus useful as a means of reducing capital expenditure on chimneys and boilers, by promoting the rate of combustion of fuel at higher rates per unit of grate area. It enables the thickness of the fire to be regulated in better accordance with the fuel size and generally promotes elasticity. It is also useful in enabling the hot gases to be compelled to pass over all the heating surface, and baffles may be introduced that would otherwise be perhaps too great a hindrance. Its economy in other cases appears to demand the fullest practicable reduction of the calories in the exhaust gases by feed-heaters, which in large stations may well be in two stages, and perhaps by air-heaters for furnace supply.

When, however, it is attempted to utilise the last remnant of waste heat let it be remembered that we are, so to speak, working near the lower end of the curve of expansion, and that for each item picked up with one hand we are paying out with the other. All attempted economies, therefore, may cease to be commercial economies before they cease to reduce fuel expenditure per kilowatt.

The following words, written over 60 years ago by the pioneer in the movement to obtain more scientific use of coal and fuel in steam raising (we refer to that remarkable man, C. Wye Williams), are still applicable to the position in this year, 1905, and there are few present who would guess that they were a quotation from a book entitled "The Combustion of Coal," published in the year 1841 in Liverpool, and dedicated to the Proprietors of the City of Dublin Steam Packet Company:—

"*It may be asked how it has happened that hitherto the smokeless combustion of fuel has not been effected. I answer, because the* chemistry *of combustion has been neglected, not in the laboratory but* in practice; *and because the construction of our furnaces has been too much left to those who know little of the chemical properties of the materials which are consumed in them.*"

Rules for Sampling Fuel.—As each barrow load or fresh portion of fuel is taken from the pile or store heap, a count is kept of the number used, and *the whole contents of each tenth or twentieth barrow or portion* are placed on one side, in a cool place, under cover. Care must be taken that the barrow or portion selected for the sample does not contain an unfair proportion of lumps or smalls.

At the end of the day, or period for which the sampling is to be carried on, the heap of fuel obtained for sampling purposes, as described above, is transferred to a sampling plate, and the larger lumps are all crushed down to walnut size. Should no sampling plates be available, four of the iron plates used for covering man-holes and boiler-flues may be utilised to obtain a hard, clean surface on the floor of the boiler house, and the crushing down of the sample may be carried out on these plates with any heavy and flat lump of iron at hand. The heap of fuel, after this first crushing, is thoroughly mixed by turning over and over with a shovel. The heap is then flattened down, two lines are made across it at right angles with the edge of the shovel, and two of the four opposite sections are selected to form the reduced sample. The lumps in this are again crushed, the sample is again mixed, and the quartering operation repeated, until 8 or 10 lb. of fuel only remain, with no lumps that will not pass through a ¼ in. sieve. Two 1 lb tins, with ordinary or patent lids, are filled from this remaining heap of fuel, after thoroughly mixing the same with the hands or with a small shovel. One of these tins is to be sent per parcels posts to the fuel expert for analysis; the other is to be kept for reference in case of dispute.

A New Telpherage Plant.

A NEW telpherage plant has been lately installed by the United Telpherage Co., in the Walter Baker Chocolate Mills, at Milton, Mass. Before this plant was constructed, the method of handling was to truck all the raw material, by a number of teams, from the freight house by a runabout route to the mill, where it was hoisted to the third floor on elevators.

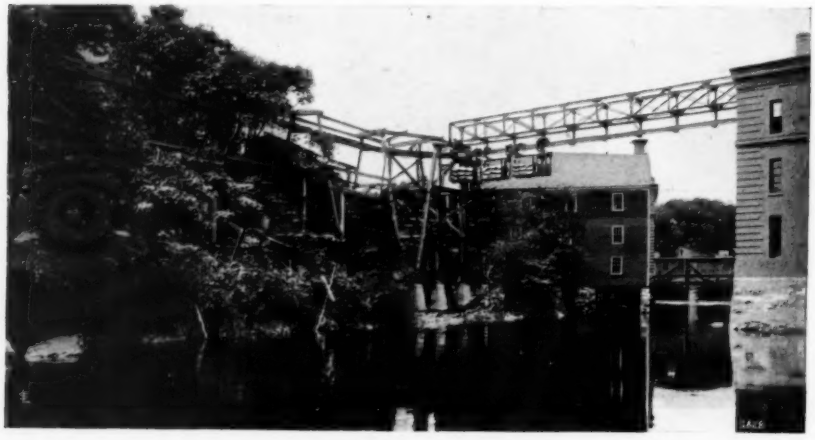
The present method reduces the distance and many of the difficulties. Bags of cocoa, weighing about 300 lb. each, are loaded nine on a truck in the freight house. Three trucks are then hitched to the machine, raised clear of the floor and deposited on the floor of the mill in less than one minute. Besides the controller, a brake handled by the operator brakes both the telpher and trailers, so that the train can be stopped in its own length. The trains are 30 ft. long, and the average speed 700 ft. to the minute. The weight of the truck is 4,600 lb., and with three loaded trucks the total moving load on the structure is about 12,000 lb.

The building of this plant presented some unusual difficulties. The only level ground traversed by the track is for a distance of 60 ft. This portion is supported by A bents, 35 ft. above the ground on concrete foundations. The track passes along the side of a cliff and across a swift-running river at an elevation of 50 ft., on a steel bridge. Foundation piers for the tower which support one end of the steel bridge are built on the slanting rock of the river bank of concrete. The top of this tower is 55 ft. above the water, and the distance between the tower and mill is 80 ft. This distance is covered by a heavy steel bridge, carrying the track beneath it. Along the cliff pine posts 14 in. square are used. Foundations for these posts were cut out of the face of the rock and are braced in the shape of a figure 4 by heavy timbers, also anchored in the rock. There are finally two curves, one 90 deg. of 40 ft. radius, the other 90 deg. of 20 ft. radius.

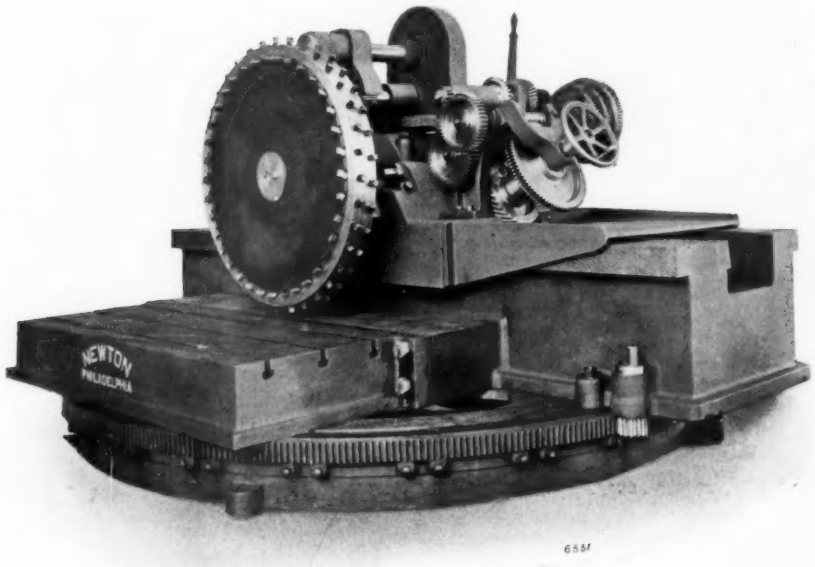
New Rotary Planing Machine on Round Base.

THE new rotary planing machine illustrated herewith has lately been built by the Newton Machine Tool Works, of Philadelphia. All the operating levers of the machine are placed on one side so that the machine can be entirely operated from platform. The machine has four changes of positive speed through gearing, with power traverse in either direction, all of which are operated directly from one motor.

A new feature of this machine is the spiral rack and pinion, used for traversing the carriage, which has a feed 7 ft. in length and is of an unusually heavy design. The head has an in and out adjustment of 6 in. for convenience in adjusting to the



NEW TELPHERAGE PLANT.



ROTARY PLANING MACHINE.

cut after the work is clamped. The rack, which is of steel, is set in the bed, and is acted on by the phosphor-bronze spiral pinion.

The cutter head is 48 in. in diameter over tools, and is driven by an internal gear ring and pinion, power being supplied by a 10 h.p. motor mounted on the opposite side of the head, not shown in the illustration, by means of a steep lead phosphor-bronze worm wheel and hardened steel worm through a train of cut gearing.

The bed is of a heavy box form and has a work-table, 7 × 3 ft., attached, which sits on a circular base and will swivel to any required angle.

This machine was designed for the heaviest class of work, and is unusually heavy, having very broad ways for the carriage, and is made either fixed, portable or on a round base as illustrated.

The Clero Crusher and Pulverizer.

THE accompanying illustration is that of a simple type of pulverizing machine of French origin which, in its action, depends upon the principle of centrifugal force. The machine consists mainly of a shaft revolving at a rate of 1,000 to 1,600 revolutions per minute, to which shaft are keyed two heavy flanges or discs that revolve with it and act as fly-wheels. In these flanges are journalled a number of successive beaters in the shape of cranked axles. The bottom of the apparatus consists of two curved perforated plates, each covering one-fourth of the circumference of a circle, and serving as screens to allow of the escape of the disintegrated matter. They are formed in two halves to allow of their being easily withdrawn and replaced without interfering with any other portion of the apparatus. Several steel cushions placed within the rear face of the casing assist in the process of disintegration. A casing and hopper for the introduction of the material to be disintegrated complete the crusher. The casing, with the hopper, pivots round a hinge to facilitate the inspection and cleansing of the apparatus, and the replacement of the beaters and screens. The action of the apparatus is as follows: On the shaft being set in motion the beaters assume, under the action of centrifugal force, a radial position with respect to the shaft, and strike the material introduced into the hopper, slightly clearing the semi

circular screen fitted in the lower part of the casing.

The particles thus struck are violently thrown against each other, and also against the steel cushions within the casing, and when reduced to the required degree of fineness escape through the screen to be carried away.

As there are usually six beaters, the material to be disintegrated receives from 100 to 160 strokes per second.

The combination of its parts is so simple that it is practically impossible to put it out of gear; steel files, iron bolts and nuts, the points of steel pick axes, have been dropped into the apparatus while at work without doing it the slightest injury. The beaters, which are made of one piece, being loose with respect to the flanges or side pieces, there is no danger of the beaters breaking in case of any violent shock, or of their causing undue strain on the other parts of the apparatus. They simply recoil, and then shoot forth again; and this with such successive rapidity that practically no material can stand it.

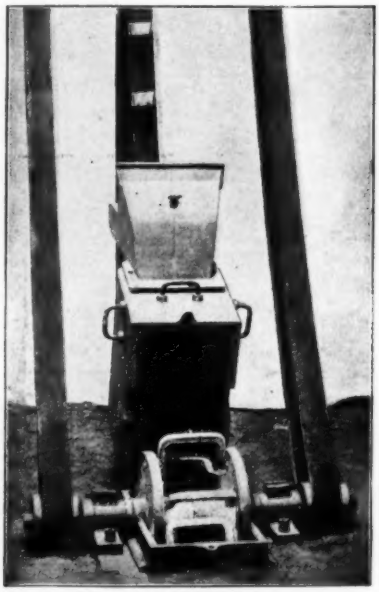
The only wearing parts are the beaters, and these are simple forgings. In order to prevent wear, all the cast parts of the apparatus are made of a mixture of steel and iron in such proportions that the greatest shocks that can occur within the apparatus will have no effect upon its walls.

The power consumed is very small, the smaller size machine requiring but 4 to 8 h.p. according to the substance to be ground and the degree of fineness required. A larger size is made, requiring from 25 to 30 h.p.

With the above-mentioned horse-power, the machine illustrated will pulverize from 2 to 4 tons per hour of such substances as plaster of Paris, barytes, cement clinker, slag, glass, coal, pottery ware, moulders' sand, and mineral ores of all kinds. The output of the large machine is from five to seven times that of the smaller, and will pulverize in one hour as much as 30 tons of gypsum.

The dimensions of the machine illustrated are as follows: Width of the chamber, 16 in.; over the pulleys, 43 in.; length, 27 in.; height, 32 in.

The Municipality of Paris has recently granted a concession for the pulverization of the town refuse of Paris with this crusher. It has been found that a No. 2 Crusher consuming 30 h.p. will pulverize 10 to 12 tons per hour of town refuse This refuse contains, among other things, glass, broken china, tin cans, broken kettles, and other



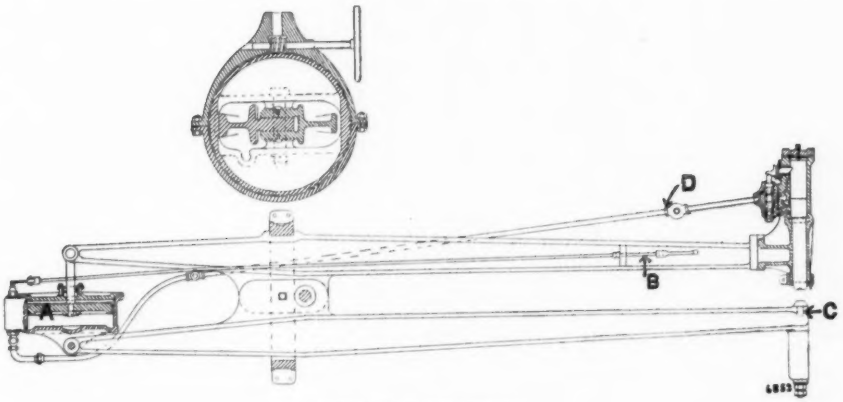
THE CLERO CRUSHER.

hard substances. The refuse is not previously picked by hand, as it formerly was, but is at once put through the crusher, and it leaves the screen in the form of a blackish mould, perfectly homogeneous, and ready to be delivered at once as manure. The machine is being introduced into this country by the Patent Clero Crusher Co., Ltd., 65-66, Chancery Lane, W.C.

New Pneumatic Boiler Riveter.

A DEMONSTRATION of a new type of a portable pneumatic boiler riveter was recently given in the Grangemouth yard of the Grangemouth and Greenock Dockyard Co., by the manufacturers, Messrs. John Turnbull, Jun., & Sons, 190, West George Street, Glasgow. Unfortunately, our editorial representative was unable to attend, but a sample of the work done at the time has been forwarded for our inspection, which has satisfied us that the $\frac{7}{8}$-in. snap-head rivets have been perfectly driven, and that the $\frac{1}{2}$ in. plates are tightly closed, making a thoroughly steam-tight job.

The machine, the details of which may be followed in the accompanying drawing,



PNEUMATIC BOILER RIVETER.

consists of two levers or legs joined with a pivot pin. At the top end of the legs is a cylinder which, when air is admitted, closes by a piston the lower end of the legs on the boiler plates with a pressure of 2,000 lb., this pressure being maintained independently of the riveting operation. This constitutes the distinguishing feature of the machine, and by its application all vibration of the U tube, which is detrimental to sound riveting, is obviated. It enables the machine to be closed on the work before the rivet is inserted and the plates to be hammered down, and any burrs caused in punching the holes flattened. The plate thus readily yields to the pressure of the arms when the rivet is being driven and prevents the hot rivet from throwing out a fin or washer between the plates.

The machine is operated with an atmospheric pressure of from 30 to 50 lb., and makes from 150 to 200 strokes per minute. The time required to form the head of a ¾ in. rivet is about six seconds, and at steady, straight work, allowing for ordinary detention and loss of time, two or three rivets can readily be finished in one minute.

The machine can be suspended either vertically or horizontally, and the operation is as follows:—

The rivet boy, after inserting the hot rivet, moves the die and weight *C* over head of rivet, when the operator admits air into the cylinder *A* by moving the rod *B*, thereby closing the ends of the legs and pressing the nozzle of the riveter upon the plates over the rivet with a pressure of 2,000 lb. The operator then presses upon the spring valve *D*, thereby admitting the air pressure into the riveter to operate its hammer, and thus forms the rivet head by a succession of rapid blows.

The machine is made in three sizes, viz., with a reach of 72 in., 84 in., and 96 in. respectively, and is capable of driving 1¼ in. rivets.

Lengthening Capacity of Armoured Concrete*

THE facts presented by M. Considère in previous papers to the Academy of Sciences, were accepted by many engineers as the foundation of the theory of armoured concrete construction. They were, however, looked at with diffidence by others, in spite of the explanation proposed by the author in his communication of 1899. Both German and American experimenters, while verifying these experiments, observed that reinforced concrete manufactured under their supervision cracked under the action of the same breaking tension as non-reinforced concrete, whence they inferred that the author was not able to detect the minute fissures actually produced.

The problem was therefore taken up again in the laboratory of the Ecole des Ponts et Chaussées. Two concrete baulks 3 m. in length and of the cross-section shown in Fig. 1 were prepared without any special precaution. This

* By M. Considère (Comptes Rendus de l'Académie des Sciences, Vol 140, No. 5, Jan. 30th, 1905).

concrete included 400 kgs. of Portland cement, 400 litres sand, and 800 litres lime gravel, the amount of water used being 9·6 per cent. of the weight of the dry materials. The reinforcement consisted of two soft steel bars 60 mm. in diameter and three bars of 12 mm., being arranged close to the surface that had to stand the greatest tension.

One of these baulks was kept in the open and covered with empty bags and planks sprinkled frequently during the first month and afterwards every two days, while the other, after one day's setting, was immersed under water and kept there. These baulks, which were manufactured on the 27th and 28th of May, 1904, were submitted to loading on the 21st of November and 22nd of December respectively. Being placed on supports ·05 m. distant from their ends, they were submitted to the pressure of a hydraulic apparatus in two points situated symmetrically at ·70 m. on either side from the middle, so that over a length of 1·40 m. the bending moment was constant and the shearing force *nil*.

In the middle of this length the tension of the surface under stress was observed over a length of 1·02 m. by means of two microscopes mounted on the same rod, the shortening of the compressed portion being measured over a length of ·50 m. by means of two Manet-Rabut apparatus placed on the lateral surfaces.

The loading was stopped at the moment when the tension of the outer fibres of the concrete was ·625 mm. with the first and 1·300 mm. with the second baulk, when under the microscope no fissures were observed in the coating of pure cement, which, in order to facilitate observations, had been applied on the surface.

The concrete, covering the reinforcement, was afterwards chiselled off, and the reinforcement withdrawn, after which the surface of the concrete was smoothed down as far as possible. The portion *A B*, Fig. 1, was then removed with a saw. When tracing the diagram of deformations it was seen that the various fibres of portions thus removed had undergone tensions intermediate between 0·22 mm. and 0·50 mm. with the first and 0 56 mm. and 1·07 mm. with the second baulk, while non-armoured concrete is known to break as soon as its tension exceeds ·10 mm. to ·20 mm.

The same plates were also submitted for bending tests, when they were found to possess a high resistivity.

For the sake of comparison, the upper

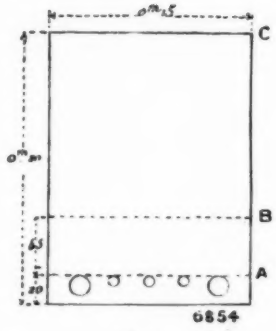


FIG 1.

parts *B C* of the same baulks were tested in the same way, and the strength, as calculated on the formula generally used in connection with bending tests, are recorded in the following table:

Baulks.	Portion tested.	Position.	Strength.
Baulk No. 1	Plate *A B*	As in Fig.	32kg. 8
,, 1	,,	Reversed	27kg. 1 & 32kg. 2
,, 1	Part *B C*	Reversed	36kg. 1
,, 2	Plate *A B*	As in Fig.	22kg. 2
,, 2	Part *B C*	Reversed	28kg. 9

In order to fully appreciate these figures, the following facts should be taken into account: The surfaces of the plates *A B* had been obtained, one by chiselling and the other by sawing the concrete, and the tool had made injuries liable to produce fissures and to hasten ruptures. On the other hand, the test of the plates *A B* having been made on November 28th and December 12th respectively, and that of the portions *B C* on January 12th, the strength of the concrete had certainly increased between these dates, especially in the case of baulk No. 2, which was kept immersed up to December 1st and out of the water since that date. On being exposed to the air, such lime as was still free must have been carbonated, thus increasing the resistance of the concrete.

It would therefore appear that not only can properly prepared reinforced concrete stand tensions of far greater value without breaking than non-reinforced concrete, but that, after considerable deformation, the concrete possesses a tensile strength comparable and, maybe, equal to that of concrete having undergone no previous deformation.

The author thinks that reinforced constructions generally show fissures, which he explains as follows: such concrete as is

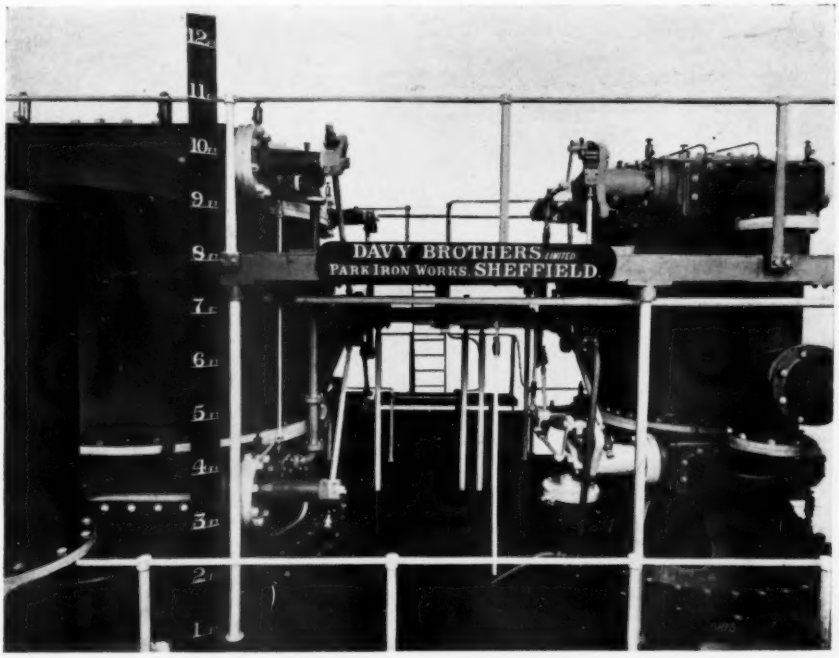
exposed to dry air, after being prepared, will undergo a very considerable shrinkage for some days, with a corresponding diminution in strength. If its contraction be resisted by a metallic reinforcement, it will neither have the force required to cause the metal to contract to any considerable extent, nor the ductility required for adapting itself to the special conditions, thus fissures will generally be produced, which—though being first invisible—will become opened and lengthened as the reinforced piece is submitted to mechanical stress. If, on the contrary, the concrete be kept continually in a moist condition for a sufficient length of time, its shrinkage will be *nil*, so that there is nothing to cause fissures during the time it assumes its strength and ductility. As a matter of fact, concrete tends to contract when no longer maintained in a moist condition, but then its resistance will be high, and it will be able to stand considerable tension, so that, in spite of the obstacle to contraction opposed by the reinforcement, it will not become cracked.

The possibility of fissures calls for sufficient cross section to be given to the reinforcement, so that this might stand the whole of the load, while accurate knowledge of the non-elastic deformation of armoured concrete is likewise indispensable.

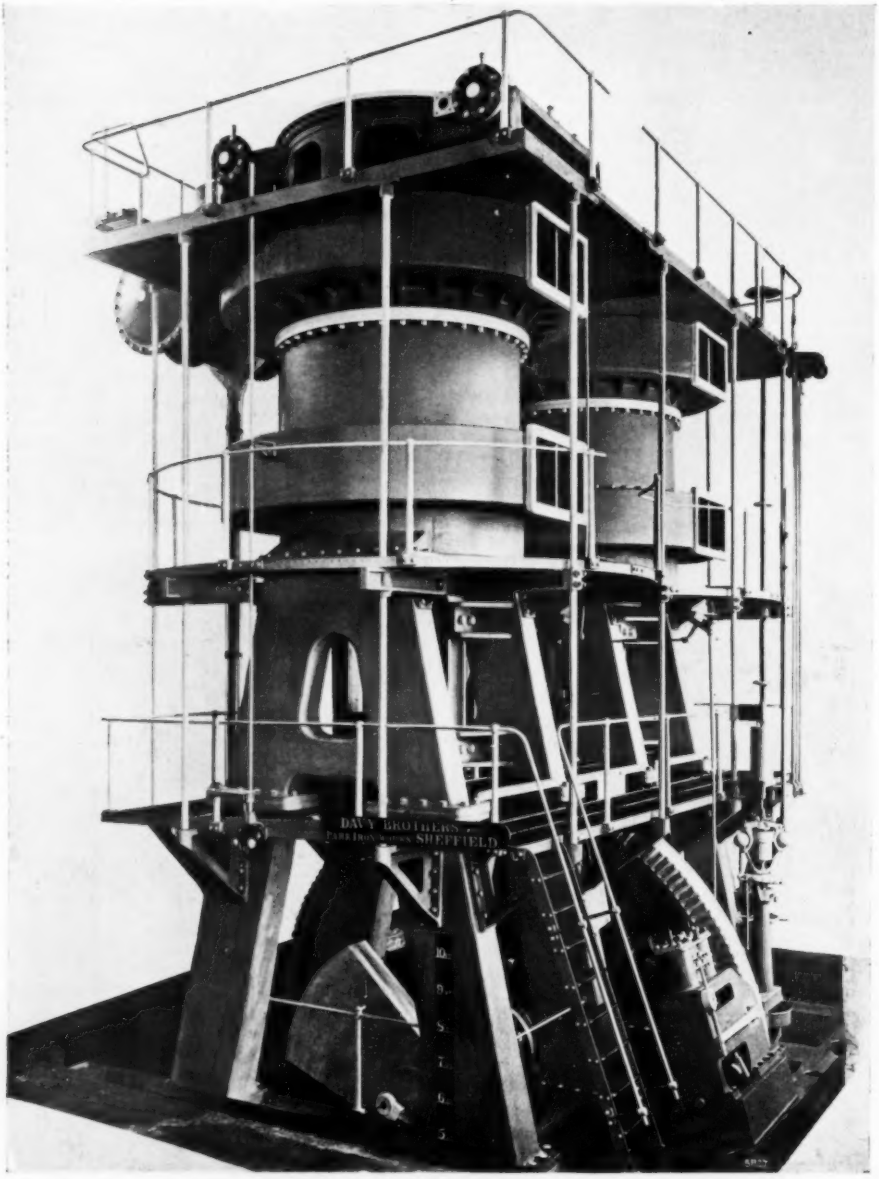
Blast-Furnace Blowing Engine.

A NEW blowing engine embodying several interesting features has recently been installed at the Acklam Works of the North-Eastern Steel Company, by Messrs. Davy Bros., Ltd., of Park Iron Works, Sheffield, by whose courtesy we are enabled to furnish the accompanying illustrations and particulars.

The engine is of Messrs. Davy's well known type, with the steam cylinders placed above the air-cylinders, and having pistons of the dished type to facilitate the drainage of water. The cylinder dimensions are as follows:—High-pressure, 48 in. diameter; low pressure, 90 in. diameter; air-cylinders, 90 in. diameter; all having a common



BLAST FURNACE BLOWING ENGINE. VIEW OF CYLINDERS AND VALVEGEAR.



BLAST FURNACE BLOWING ENGINES CONSTRUCTED FOR THE NORTH EASTERN STEEL COMPANY BY MESSRS. DAVY BROTHERS LTD., SHEFFIELD.

stroke of 6 ft. Double-ported Corliss valves are fitted to the steam cylinders. An improved radial type of trip gear has been fitted in connection with the high-pressure cylinder, the connection to the governor being such as to permit a range of cut-off from zero to $\frac{6}{10}$ of the stroke, after which the gear becomes positive in action, an arrangement which enables the engine to run at a lower pressure. Springs customarily employed for closing the steam valves have been dispensed with, and an arrangement adopted whereby the pressure for closing the valves remains constant at all points of the cut-off. Both steam and exhaust valves are driven through a wrist plate, worked from one eccentric.

On the low-pressure cylinder, trip gear, controlled by the governor, has been dispensed with, a positive gear having a fixed cut-off at $\frac{6}{10}$ of the stroke being employed. The makers have found that equally good results are obtained in this manner, and, at the same time, the working parts are reduced to a minimum. The governor is of the spring-loaded type and is adjustable, through gearing capable of being altered by means of a hand wheel, so that the speed of the engine can be regulated from 20 to 50 revolutions per minute while running.

Exhaust steam from the high pressure cylinder before entering the low pressure cylinder is passed through an intermediate jacketed receiver in which it is thoroughly dried. An arrangement has also been provided for admitting high pressure steam direct to the low pressure cylinder, so that the engine can start against the full blast pressure. The pistons of the steam cylinders and all stuffing boxes have been packed with Messrs. Lancaster & Tonge's spring packings.

In the pistons of the air-cylinders, however, no packing has been made use of, a few grooves being turned round the circumference to accommodate the lubricant. Under these circumstances great care was naturally required in boring the air-cylinders, and so accurately was this done that approximately only $\frac{1}{100}$ inch clearance all round the piston was found to exist.

The balancing of the moving parts has been effected by forged steel crank webs, each weighing about $7\frac{1}{2}$ tons and by removing a portion of the rim on one side of the fly-wheel.

A barring engine, seen in the foreground of the illustration, has been fitted. It is of the usual 2-cylinder type fitted with worm and worm-wheel, and is automatically thrown out of gear when the main engine begins running. Tests made with the engine showed that 52,000 cubic feet of air was delivered per minute at a pressure of 15 lb. per sq. in., with steam pressure at 70 lb., vacuum of 10 lb. per sq. in., and a speed of 50 revolutions per minute. The engine, however, is capable of working at 100 lb. steam pressure, when about 3,800 h.p. is indicated. Some efficiency calculations were made by Prof. Innes, of Newcastle-on-Tyne, from indicator cards submitted to him, of which the following are the particulars:—

Steam pressure	90 lb.
Blast ,,	12½ ,,
Vacuum	5 ,,
Revs. per minute	33
Efficiency of compression	92·5 p.c.
Mechanical efficiency	84·1 ,,
Total efficiency—*i.e.*, ideal work required to compress air isothermally ÷ actual work in steam cylinders	77·7 ,,

Remarking on these results, Prof. Innes states; "It will be seen from the diagrams of the air-cylinders that the pressure at discharge is very little more than the gauge pressure, showing that the discharge valves work very well; the suction lines are also close to the atmospheric line. The mean exponent of the eight compression and eight expansion curves is 1·35—*i.e.*, these curves on the average follow the law $p\,v^{1\cdot35} = \text{constant}$. The results are very good, both mechanical efficiency and efficiency of compression being very high, and, consequently, their product, the total efficiency being higher than usual. For this last 70 per cent., or 0·70, is generally considered good, and it is only too frequently found as low as 0·65, or 65 per cent."

High-Speed Electric Drilling Machines.

Messrs. Kramos, Ltd., of Locksbrook Engineering Works, Bath, have recently placed on the market a set of specialised electric drilling machines for use with the new self-hardening, high-speed tool steel.

The accompanying illustration shows a very handy type of a machine made by them known as "The Midget" drill. This is a high-speed tool drill, weighing only 15 lb. complete, and has a capacity for holes up to $\frac{5}{16}$ in. diameter at 300 revolutions per min. in hard metals, and 450 for soft metals.

This tool owes its light weight to the

THE "MIDGET" ELECTRIC DRILL FOR HIGH-SPEED TOOL STEEL.

fact of its being encased in aluminium. The magnets are of high permeability steel containing the right quantity of metal to ensure the magnetic field required. The armature is of a special type, being longer in proportion to its diameter than is usually the case. The gearing is machine cut out of solid steel blanks, and the drill spindle runs in a long bearing, and is provided with ball thrust plates. An extra strong switch of quick make-and-break pattern is fitted to the machine, being contained inside the aluminium casing and is actuated by means of a push button protuding through the casing as shewn in the illustration. This machine is more particularly useful in a workshop where a large number of small holes have to be drilled.

Other types of equal interest are described and illustrated in Messrs. Kramos' latest list of high-speed drilling machines, among which may be noted the "Slick" drill with tapping device; the "Dandy" drilling machine for operating drill heads by means of flexible or telescopic shafts; and the "Runthru" drill, which is being supplied to the Admiralty with a specially-designed magnetic brake. This tool is also encased in aluminium, the inside of which is machined at one operation on a special lathe with milling attachment, designed by the firm for the purpose. The weight of this machine is 60 lb., drilling holes of 1 in. diameter at 160 revolutions in hard metals, and with an overload capacity for short periods to drill 1¼ in. holes in steel.

In the "Dandy" drill the motor is completely enclosed in a steel casing, is compound wound, and has an output of 2½ b.h.p. at about 1,000 revolutions per minute, at full load for a 2 in. equipment, and 1½ b.h.p. at 1,000 revolutions per minute for the 1¼ in. size.

Messrs. Kramos build also drill heads with electro magnetic holders on, both of light and heavy types. This firm have made it their object to standardise all their machines, as is the practice in pneumatic drilling appliances, and to make a tool more on mechanical than on electrical principles. Practically every part in the motor has been specially constructed to withstand rough use and the wear and tear to which such apparatus is commonly subjected, and in so doing Messrs. Kramos have rendered good service to this particular branch of industry.

RAILWAY AND TRACTION NOTES.

Automatic Signalling on the Metropolitan District Railway.

ONE of the chief features of interest connected with the electrification of the District Railway is the automatic and semi-automatic signalling system—said to be one of the finest in the world—that has been specially designed to meet the special conditions obtaining on this line.

The electro-pneumatic principle has been adopted, the signals and points being operated by pneumatic motors worked by compressed air. The latter is supplied by electrically driven air compressors installed in all the sub-stations, and which pump air into a single main running the whole length of the railway. In the event therefore of one compressor being shut down the rest are available. Air pressure of 70 lb. to the sq. in. is used. The control of the pneumatic motors is obtained by a 60 volt direct-current track circuit supplied by small motor generators in the sub-stations.

One of the running rails is lightly bonded continuously over the whole extent of the line and is the positive conductor of the signalling system, the other rail being split up into insulated sections by special rail joints insulated with fibre. Two electric relays connect the rails in each section, one being placed at each end. A return main runs the whole length of the line, the sectioned rail being connected with it through resistances at that end of each section which the train leaves.

The resistances are inserted to prevent a train short-circuiting the track circuit through the motor-generators, which are of low internal resistance, and so causing a heavy increase of current at that particular circuit from the main.

A diagram of the connections is given in the accompanying figure, the explanation of which has been well given in the columns of a contemporary* as follows:—

The track coils of the relays are permanently connected across the rails. Between the pole pieces a polarised armature, bearing a winding of considerable resistance, is suspended from a pivot. This armature is connected between the positive rail and the negative main through a contact—operated by the track coil armature—which is closed when the track coils are energised. To the polarised armature is rigidly connected an arm which actuates a contact, the function of which is to open or close the local circuit controlling the signal motors. It will thus be seen that when there is no train on the section the relay track coils are excited and draw up their armature, which closes the circuit through the polarised armature. The latter is then attracted to one of the poles of the relay, and so closes the contact in the local signal circuit. The two relays in each section are duplicates, and the contacts in the local signal circuit are in series. Unless both these contacts are closed no current can flow through the signal magnet, and the signal will therefore remain at danger by gravity.

When a section is unoccupied by a train, current passes from the continuous rail by way of the sleepers and ballast and through the relays, all in parallel, to the sectioned rail, and thence to the negative main through the resistance previously mentioned. This resistance is adjusted in relation to the combined resistance of the relays and ballast (in multiple), so that there is a potential drop between the rails of from two to five volts, the remaining drop from 55 to 58 volts being across the resistance itself. When a train comes on the section, the two rails are short-circuited through the car wheels and axles, the resistance of which is negligible, and the relays are thus de-energised. This opens the circuit through the signal valve magnet in the motor, which is thereby de-energised, resulting in the closing of the connection between the motor cylinder and the air main, and the opening of a port from the signal cylinder to the atmosphere. Thus the air pressure is taken from the motor piston and the signal goes to danger by gravity.

The track circuits are carried through the

Tramway and Railway World, February 9th.

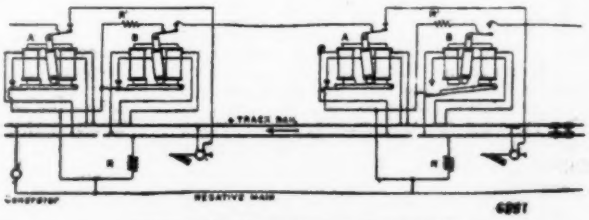


DIAGRAM OF AUTOMATIC SIGNAL CONNECTIONS.

interlockings, and here it is evident that many cases arise where several signals, all giving access to the track-circuited section, are controlled by the same. The actual signal that is lowered depends, of course, on the position of the points.

All signals outside interlocking limits are entirely automatic. At interlockings the signals are semi-automatic, that is to say, the signalman cannot pull such a signal off to clear unless the track-circuited section to which it gives access is unoccupied by any vehicle. If after the signal has been pulled off by the signalman a vehicle enters the section from either end, the signal is automatically thrown to danger, and remains in this position, even after the section is unoccupied, until the signalman replaces his signal lever to its normal position and again pulls it over. The signalman can place a signal to danger at any time by putting his signal lever back. A semi-automatic signal may thus be said to be "slotted" by the track circuit.

Both signals and points at junctions and cross-over roads are worked electro-pneumatically from a locking frame, such frames being of the Westinghouse Brake Company's standard type as installed on other railways.

There is no point on the District Railway where a train is not automatically protected, as the whole of the company's lines is track-circuited. Every train, as soon as it gets on the main line, is under the protection of the track circuit through interlockings and between interlockings. Moreover, in the majority of cases the yards as well as the sidings are track-circuited. While a train is in a siding, under certain conditions, the train holds the siding or shunting signal at danger. Under other circumstances the track in the siding controls no signal, but gives the signalman in the cabin a visual indication of its condition. The signalman, looking at his indicators, can tell the position of the various trains in the sidings throughout his yard. This is effected by means of a new feature which has never before been used. In place of the ordinary cabin diagram showing the lay-out of the yard and the situation of points, signals, and so forth, an illuminated diagram is installed in the signal-box on which the position of every train in the near neighbourhood is shown. This diagram consists of the ordinary drawing of the lay-out of the yard, the signal positions, etc., but in addition the four-foot way on the diagram is illuminated from behind by electric lamps. These lamps are controlled by the track-circuit indicators in such a way that when a train enters a given track circuit the lamps behind the diagram which illuminate the section of the line on the diagram corresponding to the section occupied by the train are extinguished, thus showing that the track circuit is occupied by the train in question. When the train passes into the next track circuit the previous track circuit is reilluminated, while the lamps behind the representation of the latter one go out.

Of the precautionary arrangements adopted in connection with the system, the most important is that provision has been made against the relays being energised, and consequently the signals operated by extraneous current from the traction circuit. Further, if a running rail should break, the signal for the section is at once thrown to danger. Another arrangement is the "train stop,' provided alongside the track at each signal.

It consists of a short arm which, when the signal is at danger, is raised vertically to such a position that it engages with a cock on the passing train, opening it, and applying the brakes. This, of course, only happens should the driver of a train over-run a danger signal. The pneumatic motor arrangement actuates the stop in the same way as it does a signal. The stop is held by the compressed air in the clear position, and it returns to the danger position when the air pressure is relieved. When the signal stands at clear, the stop arm lies horizontally, allowing trains to pass without interference. Each track circuit overlaps the signal under the control of the following section by a distance greater than that required to bring the train to a dead stop if it received, when passing the signal, an emergency application of the brakes. Therefore, a train standing at the extreme rear end of a block section always has a sufficient distance between it and its protecting signal to ensure a following train being brought to a dead stop before collision, even if the latter should attempt to run by the signal at full speed.

As to economy, the total energy used in this track signalling averages less than half a kilowatt per mile of double track.

There remains one important improvement which has never before been employed on any railway. With a close headway it is very important that trains should not be held by interlocking and by junction points waiting for the routes to be set up. It is also necessary that the passengers waiting on the station platforms should be notified of the destination of trains approaching the stations.

To effect these ends, a patented system of magazine train describers is now being installed. These consist of apparatus which is operated from signal cabin to signal cabin. For instance, cabin A sends a describing electric impulse to cabin B giving the destination of the train which is passing cabin A. The apparatus is of a magazine type, so that cabin A can describe to cabin B any number of trains according to the capacity of the railway between A and B, before the first of these trains arrives at B. These descriptions are received and stored automatically at cabin B, and can be produced at the signalman's will in the exact sequence in which they were received. Thus the signalman always knows the destination of trains approaching his cabin, and he is accordingly

enabled to adjust his points and clear his signals for the train to pass through his interlocking without delay. The descriptions sent from cabin A are also received by the intermediate stations between A and B, and they automatically show on the station platforms by means of an illuminated sign the destinations of the three trains which will next arrive at the station in the sequence in which they will arrive. Each train cancels it own illuminated destination on leaving the platform, number two on the indicator becomes number one, number three becomes two, and a new train destination shows up as number three.

As will be plain, the whole scheme is of the most elaborate description, and it promises well both for the expeditious and safe working of the proposed frequent train service and for the convenience of the public.

The Amsterdam-Haarlem Electric Railway.

THE inauguration of the electric line connecting Amsterdam, Haarlem and Zandvoort a month or two ago, marked the completion of an undertaking beset with engineering difficulties of no ordinary character, involving miles of sheet-piling and an enormous quantity of sand filling. If to this be added those connected with the obtention of the concession and the stringent conditions imposed during the carrying out of the work, the undertaking assumes features of more than ordinary interest, and, in fact, it is doubtful if a parallel instance exists anywhere else. Through the courtesy of the engineers and contractors, Messrs. J. G. White & Co., Ltd., we are able to give some leading particulars of this interesting line:—

About five years ago, a local Dutch company constructed in the city of Haarlem the first electric tramway system in Holland. This system included a belt line around Haarlem, with two suburban branches—one running north to Bloemendal, a residential suburb; and another west, about five miles, to Zandvoort, an important seaside resort for the people both of Haarlem and of Amsterdam.

Haarlem, a city of 65,000 inhabitants, is ten miles distant from Amsterdam, and a concession secured several years ago to construct an electric line between the two cities was only prevented from being carried out by the Holland Steam Railway Company having secured control. In 1901, however, preliminary steps were taken towards securing a new concession over the direct Government High Road connecting the two cities and running parallel with the steam railroad.

The essential conditions of this concession for the construction of a double track line on each side of the Government High Road were:—(1) That the concessionnaire was required to sheet pile the sides of the road (which is bordered by a canal on one side and a ditch on the other), in order to secure the necessary width and stability, and to carry out the whole of the works with the least possible interference with the regular use of the road. (2) The period of the concession was for fifty years. (3) The speed allowed for the cars was to be regulated by the Secretary of State, and the speed actually permitted was thirty-five kilometres per hour. (4) At the expiration of the concession the Government take over, without compensation, all the property of the company located on Government lands.

In addition to this concession it was necessary to obtain an entrance into Amsterdam, for which purpose the concessionnaires obtained options on a private right of way for about two miles, and also running powers over the tramways of Amsterdam for a distance of about one mile from the city limits to the centre of the office and retail business districts. The gauge of the Amsterdam city lines being standard and the gauge called for by the new concession being one metre, it was necessary to lay a third rail for the greater part of this distance, where the lines are common, to permit through run-

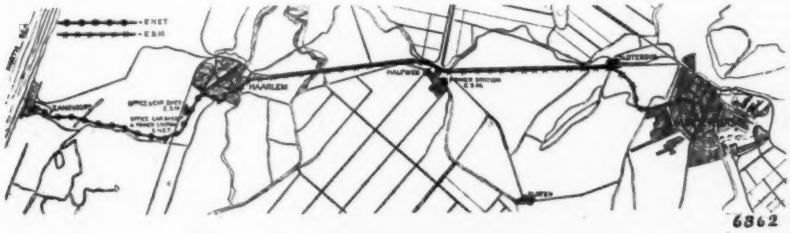


FIG. 1.—MAP OF THE AMSTERDAM-HAARLEM RAILWAY.

ning of cars over the Corporation route, this work being carried out by the Corporation at cost and a percentage. This was made more expensive by the fact that a large swing bridge had to be constructed, to permit the through running of the cars, and this was done principally at the expense of the concessionnaires. In addition to paying for this bridge and construction, the concessionnaires agreed to pay 40 per cent. of the fares which the town would have charged within the city limits, on the basis of its own rates, and also to repay the actual cost plus 10 per cent. expended by the Corporation for repairs and maintenance of the tracks used by the concessionnaires, and, further, to pay for power within the city and taken from the city's trolley wire, at a rate of not less than 0.9d. per car mile.

It will be noted that the conditions are most stringent, and that a net profit on the running in the city of Amsterdam could not be looked for; but, on the other hand, the distance within the city was a very short one (1.4 mile in a total run of 12), and to secure the satisfactory terminal facilities, these concessions were necessary.

On the other concession arrangements it is unnecessary to enter, and it will suffice to mention that when these were completed, contracts were entered into, in January, 1903, with J. C. White & Company, Ltd., for the complete design and construction of all the works required. The operation of the completed system was commenced in October, 1904.

Route.—Within the city of Amsterdam, the greater portion of the line follows the existing tram line of the Municipality, and on such portions a third rail was laid, the existing gauge being standard, while that of the new line is one metre. Connecting this section with that laid on the private right of way before mentioned is the Kostverloren Vaart bridge, constructed by the Municipality and charged to the railway company.. It is of the bascule type, and is operated electrically. This type of bridge is not easily adaptable for an overhead construction, and therefore the cars run by momentum across it.

From the bridge the line runs over the private right of way, the length of which section is 2,444 metres.

The cross section of the road over the greater portion of this part of the route is 22 ft. from building line to building line, and in the centre a strip eight metres wide is left for the tramway tracks with centre pole construction. The average surface of the ground was 1 metre 60 below the Amsterdam datum, and the height of the finished road was plus 70, making a fill of 2 metres 30. The total fill was 160,000 cubic metres. The total amount of sand brought on the work to make this fill was 280,000 cubic metres. There was, therefore, used on the work 120,000 cubic metres more than shown on the embankment. This was due to the bad soil, the additional amount sinking into the ground. The sand was brought in scows from a distance of twenty kilometres from the work, and was unloaded from the canal, by means of elevators, into trucks, and hauled by engines on the work. On this section, two steel bridges of five-metre span and one wooden bridge had to be built.

At the village of Sloterdyk the line joins the Government High Road between Amsterdam and Haarlem. The ground over this distance is what is known in Holland as "Polder land"; that is, below the canal level, and is of a boggy, peaty nature. It was in this length that the piling before mentioned became necessary.

On the north or canal side of the Government Road the distance from centre to centre of the piling is 1.25 metres. The piles are of heavy kolders or hellens (special piles), 22 cm. diameter at the top and 10 cm. at the point, the length being 5 m.

A purlin 13 × 20 cm., of squared pine, is carried along the total length of the piling, which is bolted with a 16 mm. bolt, with a washer 6 mm. thick, 70 mm. diameter.

These bolts are made with square heads countersunk into the wood. Behind this purlin a row of planks 6 cm. thick, 2.50 m. long, are driven in, each plank being 28 × 30 cm. wide. The joining of these planks is of fish-mouth construction, and each is fixed on the purlin with three spikes 15 cm. long.

At the back of every other pile, two anchor piles are driven in, 3 m. long circular section, and at the head 13 cm. diameter, and the point 10 cm. diameter. Behind these anchor piles, which are 60 c.m. centres, there is an anchor plate made of wood, 50 cm. long, 13 × 15 cm.

These anchor plates are joined to the sheet piles with 25 mm. round iron rods, 3.30 m. long, and are provided with the necessary threads, nuts, and washers. The end of this anchor is bent round the piles, and fixed with a staple. The thread for the iron anchor rods is of sufficient length to allow for the drawing up of the piling.

On the south side of the Government Road the piles are of roughly-dressed creosoted firwood, 6 m. long, 22 cm. diameter at the head, and 18 cm. at the point, the distance between the piles, centre to centre, being 1.10 m.

The back of this piling is shuttered with board 5 cm. thick, of creosoted pine, the joints being covered with strips of timber.

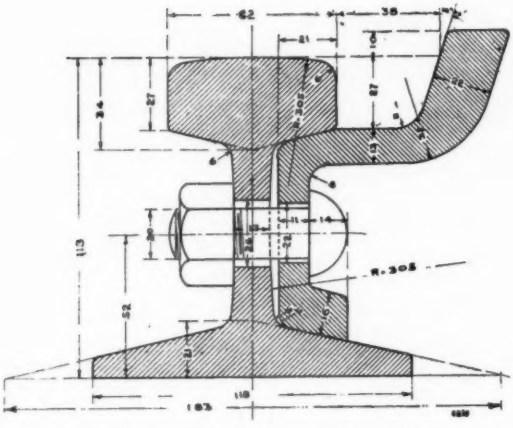


FIG. 2.—SECTION OF T RAIL AND ROLLED GUARD.

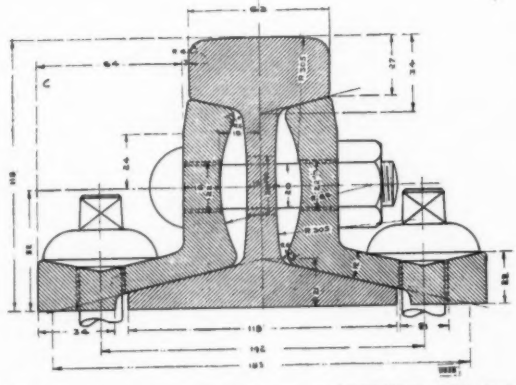


FIG. 3.—DETAILS OF RAIL AND JOINT USED ON GOVERNMENT HIGH ROAD.

This shuttering is made at such a depth that the bottom is 10 cm. below the summer level of water in the ditch.

Below this shuttering is a purlin 8 × 18 cm., behind which is driven a row of fir planks 6 cm. thick, to a depth of 3 m.

For anchoring every alternate pile, two anchor piles, 3.50 m. in length, of creosoted pine are driven in, and behind these anchor plates 13 × 15 cm., 0.80 m. long, are fixed. These anchor plates are connected with the purlin by a 25 mm. round iron rod 4 m. long, and are provided with thread, nuts, and washers.

Behind the sheet piling the filling has been carried out, pure sand being used. A coarse gravelly variety is used under the sleepers for a depth of 15 cm.

At the south side, where the height of the slopes is more than 50 cm. above the top of the sheet piling, the slopes are built up with sods in graduated layers; the remaining slopes and the surface of the filling, so far as the sleepers, are covered with either sods or turf 10 cm. thick. Where turf is used, grass seed has been planted.

The slopes in the canal side above the sheet piling are covered with basalt. For this purpose, a layer of broken bricks 12 cm. thick is laid on the sand filling, and on this the basalt is placed, 20 to 25 thick, with a slope of 1 in 1. The pitching is well joined together, and the joints filled in with small pieces of basalt, the top part being covered with sods.

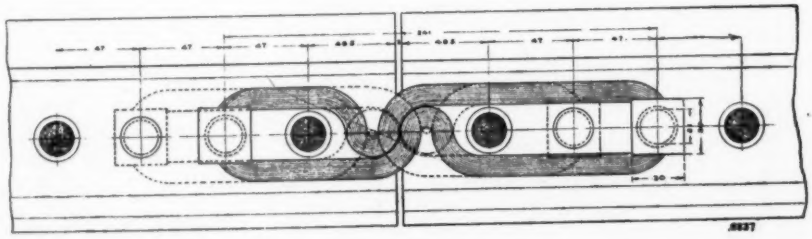


FIG. 4.—DETAILS OF RAIL BOND.

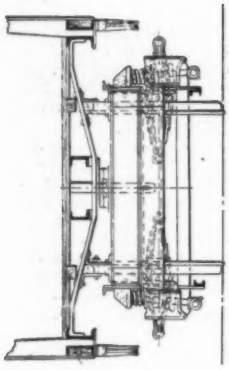


FIG. 5.—DETAILS OF CAR TRUCK.

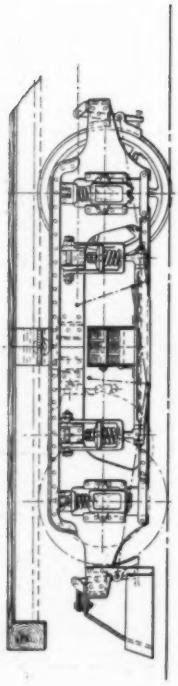
The broken bricks are not of smaller size than half a brick, and of not inferior quality than hard brick. The basalt is as regular in shape as possible, and at the top not smaller than 22 c.m. in diameter.

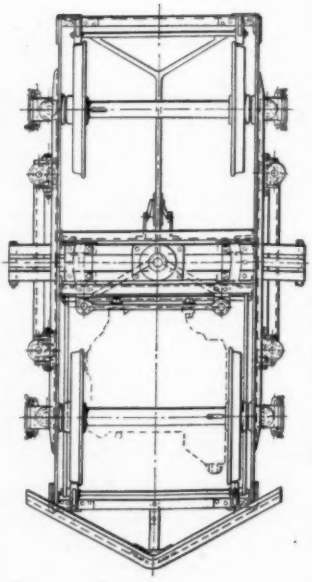
Permanent Way.—The permanent way along the Government High Road and also along the private right of way is practically a steam railway construction. The rails are of T-section, weighing 70 lb. per yard, and are standard section of the American Society of Civil Engineers for that weight, and rails rest directly on the sleepers spaced 76 cm., except at the joints, where they are 50 cm. The joints are staggered. The sleepers are creosoted Norway pine, 23 × 11.5 cm. The rails are fastened to the sleepers by screw bolts. Double concealed bonds are placed at each joint (Fig. 4).

At the village of Halfweg there are two sections of single line controlled by an automatic electric signalling device of the Siemens-Schuckert Company.

The construction in Haarlem is all grooved girder rail of 84 lb. to the yard, and resting directly on the sleepers, spaced 74 cm., except at the joint, where they are 56 cm.

In Haarlem, it was necessary to reconstruct a swing bridge, and to entirely rebuild three other bridges, and to construct a new bridge for the tram-line only at the Amsterdam Gate.





Power Station.—The power house is situated in a central position at Halfweg, midway between Amsterdam and Haarlem, practically in the best position for distributing power to the line, being located on the banks of the Ringvaart Canal, which will afford cheap carriage for coal and other supplies, and also abundance of water for feed to boilers and jet condensation.

Owing to the nature of the country and the poor condition of ground, an elaborate arrangement of piling was necessary, the entire site being piled with 46 ft. long × 9¾ diameter piles, placed 4 ft. 1 in. apart, each pile being estimated to carry 4 tons. On top of piles, runners 7⅞ in. × 9¾ in. are carried entire length of building, and support a floor 3 in. thick over the space occupied by building. The piling is carried below the water level to a distance of 3 ft. 7⅜ in., and from this point the foundations rise to the floor level—a height of 7 ft. 2⅜ in.

The buildings are of brick, finished with stone trimmings. The ground area occupied by the power station site is about

9,150 sq. ft., with sufficient ground for future extensions. A wharf is erected, 26 ft. 3 in. wide, and immediately adjoining is the boiler-house, which is 88 ft. 7 in. × 52 ft. 6 in. The engine room is 59 ft. × 34 ft. 7½ in. × 21 ft. 4 in. high. The travelling crane works over an area of the engine room at a height of 15 ft. The gantry construction is of T-rail, resting on wooden beams and supported on brick arches.

The main engine plant consists of three Belliss patent self-lubricating, three-crank, triple expansion engines, each of 430 b.h.p. and having a steam consumption of 13¼ lb. with superheated and 17 lb. with saturated steam, with 26 in. vacuum.

The boiler house contains six Lancashire steel boilers by Stork, of Hengelo, Holland, the heating surface of each boiler being 926 sq. ft.; grate area, 35 sq ft.; steam pressure, 160 lb. per sq. in.

There are six superheaters, placed in flues directly behind boilers and arranged to work at a temperature of 500 deg. F. By means of flue doors the superheaters can be cut out and engines worked by saturated steam.

The generators, which are continuous current, compound wound, six-pole machines, are three in number, and are coupled direct. The output of each machine is 300 kws., at 525 to 575 volts, when running at a speed of 375 r.p.m. The remainder of the power house equipment calls for no particular mention.*

Rolling Stock.—The cars are divided into two compartments, the larger for seating twenty-two passengers and the other twelve. The smaller compartment is for smoking. The cars are vestibuled. Besides the hand brakes, the equipment includes a Christensen air brake supplied by Messrs. R. W. Blackwell & Co., Ltd., London. The special feature of the trucks (Fig. 5) is that the swing hangers are pivoted on the outside of the truck frame. This permits a maximum distance between the supports of the spring plank, and a maximum distance, centre to centre, of the swing-hangers. The result of this construction has been most satisfactory. The trucks are very easy riding, even at the higher speeds of 35 to 40 miles per hour.

The motors are 50 h.p., and were furnished by the Union Elektricitats Gesellschaft, now incorporated with the Allgemeine Electricitats Gesellschaft.

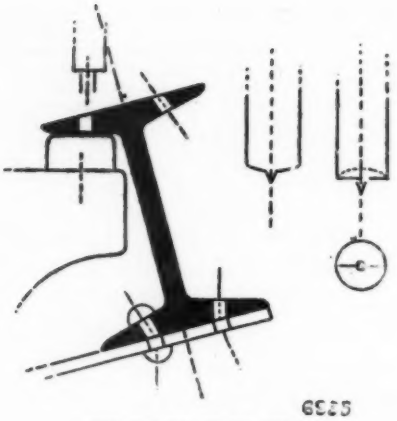
The overhead equipment is on the bow system, with a pressure of 500 to 575 volts. The poles are of the lattice girder type, of three different weights, viz., 250 kilos, 317 kilos, and 590 kilos respectively. The first two are constructed of two channel sections bolted together, and the latter with angles. The bracket arms consist of two channel sections bolted together. Bracket arm construction is used throughout, except in Haarlem, and the poles carry both the feeder cables and telephone wires. The feeder cables consist of two bare copper conductors, each 194 sq. mm. section. The trolley wire is 68 sq. mm. in section. On that part of the route from Haarlem to Zandvoort bow contact is made with two wires simultaneously. The trolley wire is zigzagged, in order to equalize the wear on the bow. The whole overhead construction impresses one with a sense of lightness, without loss of strength.

* A full specification appeared in *The Electrical Engineer* of January 6th, 1905.

Punching Structural Steel for Tenders.

TENDER frames are almost universally made of structural steel shapes, channels and I-beams being most commonly used. The punching of these rolled shapes is done in various ways, and in many shops the effort has been made to do the punching so that the axis of the holes shall be parallel to the web of the rolled sections, and of course all will be parallel to each As the inside of the flanges in structural steel are at an angle to the flat level, outside of the flange, when holes are punched with axis parallel to the web, there is generally a bevel-faced die put on the lower jaw of the punch to accommodate the sloping underside of the flange. In addition to this the bottom edge of the I-beam, etc., has generally to be held in toward or against the machine, as the downward stroke of the punch has a tendency to cause the work to slip off on the bevel die and so necessitate its being brought back into line again. This method of punching keeps the rivets quite straight when other members are joined to the steel shape.

In one of the leading American railway shops a representative of *Railway and Locomotive Engineering* recently came across a method of working by which the punching was done without reference to the parallel idea as far as the axes of the holes were concerned. In this case the bevel side of the flange is laid flat on the die and the descending punch encounters the upper surface of the flange at an angle. This method of punching causes the holes to be as they appear in the illustration. A reamer, when run through before rivets are applied, somewhat modifies the angle at which the hole is punched, b t the rivets



PUNCHING STRUCTURAL STEEL.

when driven are not straight; the important point, however, is that the holes of the I-beam and the plate are absolutely in register, and as the rivet is made to fill both holes, and as there is no vestige of a shoulder at the point of union, the bending of the axis of rivet is not thought important. In fact, a certain advantage is claimed for it, and that is that the bent rivet lessens the strain on the rivet heads, and the punching can be done without any specially constructed supports or apparatus for holding the steel I-beam or channel in place. A shearing punch is not necessary, but the face of the punch should be flat or slightly hollow, and not rounded.

A Comparison of Alternating-Current Railway Systems.

THE application of electricity as motive power to replace steam locomotives, may be considered one of the leading questions of the day. Although much has been accomplished in this direction during the past five years, the problem of finding an electrical substitute for the steam locomotive on trunk railways is still far off a solution, no apparatus having been presented which can be considered safe and practically satisfactory. In a recent paper,* Mr. J. H. Halberg reviews the various alternating-current railway systems at present employed and gives a general specification to whic an electic railway system should comply.

There are four different systems and types of locomotives which have been subject to many discussions:—

1. The polyphase, alternating-current, high-voltage, transmission system in conjunction with the direct-current, low-voltage distribution system, with sub-stations and direct-current locomotives. This system is now being installed for the New York Central Railroad. (See Fig. 1.)

2. The three-phase, alternating-current, high-voltage, transmission system in conjunction with high-voltage three-phase distribution system and high-voltage locomotives with three-phase induction motors. This system is in practical operation in Europe. (See Fig. 2.)

3. The polyphase or single-phase, alternating current, high-voltage transmission system in conjunction with high or low voltage single-phase distribution system and high or low voltage single-phase locomotives equipped with single-phase alternating current, commutator type motors geared to the axles. This system has not been tried on a large scale. (See Fig. 3.)

4. The single-phase, alternating-current, high-voltage transmission system in conjunction with high or low voltage, single-phase distribution system and locomotives equipped with motor-generator sets, which receive high or low voltage, single-phase, alternating current and deliver direct current at variable voltage to the driving motors, which may be of any suitable direct-current type. This system is in practical operation in Europe. (See Fig 4.)

System No. 1 requires three high-tension and at least two low-tension wires the entire length of the railway.

Sub-stations must be erected and maintained about five miles apart along the railway. In each sub-station will be located the usual complement of switchboards, protecting devices, step-down transformers and rotary converters of approximately 2,000 kw. capacity for each locomotive and trains.

It is probably not practicable to build rotary converters of larger capacity than 2,000 kw.; therefore, each sub-station will have to be provided with one rotary converter and step-down transformer for each large locomotive which may be supplied with power therefrom.

The failure of one sub-station from damaged primary wires, fire, or other cause may seriously interfere with the operation of trains on several miles of track; and it may be difficult, if not impossible, to promptly supply power to the dead sections.

The above may not apply to the New York Central System, where the distance con-

The Electrical World and Engineer, January 14th, 1905.

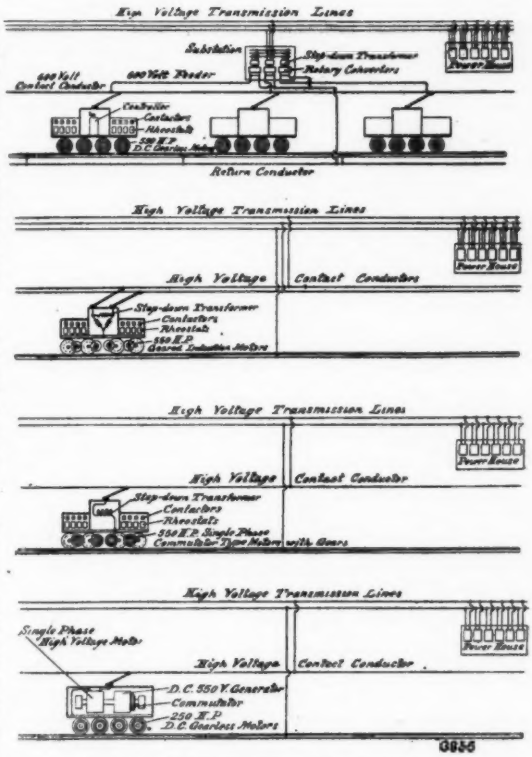
sidered is very short and sub-stations are very close together, and where the system is constantly inspected and repairs can be made promptly, but would have to be considered if this system should be used for trunk line service.

The locomotive for this system operates at about 600 volts. At this voltage a 2,000 h.p. locomotive would have to collect through sliding contacts, at a speed of 65 miles per hour, not less than 3,000 amp., which may be difficult in the open country, under certain weather conditions.

With this system it is necessary to close and open the main circuit which supplies power to the driving motors under full load and sometimes under overload. On account of the large amount of current to be handled, the switches or contractors are subject to severe arcing, and they will consequently require considerable attention and repair.

The motors for this locomotive are of new design, with the armatures and commutators mounted directly on the driving axle.

The air-gap between armature and fields is about $\frac{3}{4}$ in., and the fields are moveable relative to the armatures. Taking these facts and the fact that the armatures, commutators, brush holders, and brushes are constantly vibrating into account, it seems hard to realize good commutation and service from these motors on a track less perfect than that of the New York Central Company.



FIGS. 1-4.—ALTERNATING CURRENT RAILWAY SYSTEMS.

The failure of one motor may reduce the speed of the train to a considerable extent, by reason of the fact that commutator type motors may not be forced much above their normal rating for any length of time.

However, if the expectations of the designers and engineers who have developed this locomotive are realized in practice, and the up-keep of this system does not prove to be excessive, it may be applicable to trunk line service, where the distance considered is not too great and the trains run very close together, and have to be started and stopped at frequent intervals, which necessitates rapid acceleration. The cost of the distribution equipment for this system is necessarily very large; therefore, and for other reasons understood by those familiar with the subject, this system is not applicable to trunk line railways in general.

System No. 2 requires three high-tension transmission wires and two high-tension contact conductors along the entire railway, and each locomotive has to be provided with at least two contact devices.

On the locomotive is located a step-down transformer, which receives the primary high voltage, which is then transformed to lower voltages suitable for the three-phase induction motors, which may preferably be geared to the axles.

The usual equipment of conductors, rheostats, and other controlling devices will be required on this locomotive; but it is not always necessary to place the controlling devices in the main motor circuits, but they may be connected in the secondary circuits of the motors, which somewhat reduces the complications and the liabilities of trouble.

While this system has been entirely satisfactory in Europe, where small locomotives not exceeding 1,000 h.p. each are required for short distances, it would not be practical with 2,000 h.p. to 4,000 h.p. locomotives, inasmuch as the large lagging currents which are always present when induction motors

are started would seriously interfere with the regulation of the primary distribution system, which may prevent proper operation of other trains on the system.

In order to reduce the lagging currents as much as possible, the air-gap between the stator and the rotary member of the induction motors has to be comparatively small; therefore, the induction motor is somewhat at a disadvantage in this respect, if used in connection with a static transformer connected directly to the primary system.

The necessity of two conductors along the entire length of the railway and two contact devices on each locomotive practically prohibits the use of this system for long distances.

For System No. 3 only two high-voltage transmission wires and one high-voltage contact conductor will be required along the railway, and each locomotive is provided with only one contact device. A step-down transformer may be located on the locomotive, which will transform the primary into a lower secondary voltage, suitable for series-wound commutator-type motors, which may have to be geared to the axles.

The single-phase, commutator-type alternating current motor has not been put into practical service in large units, and the effect of starting a locomotive equipped with 2,000 h.p. to 4,000 h.p. motors of this type directly from a primary distributing system is yet to be determined.

The capacity of the transmission wires and the contact conductors and the number of feeders for this system will probably have to be greater than for any other single-phase system in view of the comparatively low power factor of the motors at starting.

The air-gap between the armature and the fields of this motor should be as small as possible, in order to maintain a high power factor, which is another disadvantage of this type of motor.

Compared with the polyphase motors, the weights and dimensions of the single-phase motor will be considerably greater, and the efficiency of the series commutator type motor is comparatively low, especially when it has to be geared to the driving axles. In view of the above, it is doubtful if large electric locomotives, as referred to, can be equipped with single-phase commutator type motors for trunk line railway service.

In System No. 4 the distribution system is practically the same as that described for System No. 3.

The contact device collects high-voltage current, which is used for operating a single-phase synchronous motor, which drives a direct-current generator on the locomotive. The direct-current generator is under the control of the operator, permitting the application of any desired voltage on the driving motors, which may be of any direct-current type suitable for the purpose.

There are many advantages in having a motor-generator set mounted on the locomotive, and it permits absolute control of the current for the driving motors without controllers, switches and resistances in the main circuit, and all changes in the power applied to the motors are gradual and do not interfere with the regulation of the primary distribution system. On this account the power factor of the primary current required by the locomotive may be maintained at unity, which will materially reduce the capacity of the power and distribution equipment.

This locomotive will return energy to the primary system, due to the momentum of the train, whenever desired, which is considered of advantage when the train is coasting.

This system has been applied to a section of the State Railway in Switzerland, and is reported to have reached a high state of development. However, as the generator on the locomotive is a direct-current machine, it has to be equipped with a commutator, and, permitting good commutation, the speed of the single-phase motor and this generator will have to be comparatively low, which means that the motor-generator set will be large; therefore there is not sufficient room on one locomotive to place a motor-generator set larger than 1,000 h.p., which, of course, limits the usefulness of this locomotive, unless two or more are operated in parallel in one train. The necessity of one commutator on each motor-generator and one on each of the driving motors is probably the greatest drawback to this system for trunk line railway service.

The author concludes an interesting paper with a description of a system proposed by himself, in which high tension current either single or polyphase is collected by a single contact device on the locomotive on which it furnishes power for a single-phase synchronous or induction motor, which drives a 3-phase generator, in turn supplying current to driving motors of the 3-phase induction type.

METALLURGICAL PROGRESS.

By PERCY LONGMUIR, National Physical Laboratory.

Blast Furnace Practice.

*Desiccated Air for the Blast Furnace.**—Mr. Gayley's paper on dry air has aroused and is still exciting much interest in metallurgical circles, more especially on the Continent. The general concensus of opinion is that the favourable results published are based on trials of insufficient duration. Mr. Gayley's results were given in diagrammatic form in our January issue, and showed with dessicated blast a considerable decrease in coke consumption per ton of iron produced. Whether the economies are due to the exclusion of water vapour or not, time and experiment alone will show. The various features of the discussion are, however, of considerable interest.

Thus, M. Heurteau, writing in the *Revue de Métallurgie*, of impressions gained from a visit to the Isabella Furnaces, speaks of the regular results, and quotes with some reservation the saving of 20 per cent. in fuel. The interest excited in this process in America takes a particular value in view of the indifference to what in Europe are regarded as essential economies, as, for instance, the utilization of coke oven bye products, the application of furnace gases to steam raising and as a source of power in gas engines. Therefore, in view of this indifference to what in Europe are proved economies, M. Heurteau concludes that there must be good reason for the American interest in the Sayley process, and that the interest will not be confined to America.

In the same issue, Professor Le Chatelier* most ably discusses the process, arguing that as the results are of so high a value, critical discussion and further experiment are essential before final acceptance. Initially, three questions are raised:—

1. Are the results exact?
2. May similar ones be obtained in our country (France)?
3. To what cause may the results be attributed?

As to the exactitude of the results, there is, of course, no question; but in experimental work of this kind one may, unconsciously or by force of circumstances, vary simultaneously factors in the problem studied, and in interpreting the results a value may be attached to one variable which in reality belongs to another. Further, in work of this character particular care is given to every detail, and as an analogy steam engine trials are quoted, for during trial much better results are obtained than in ordinary practice. Thus, in Mr. Gayley's experiments, on the introduction of dried air, the temperature of the blast rose from 385 deg. to 465 deg., no precise indication as to the source of this rise being given, though it may be due to cleaning and more effective working of stoves. Professor Le Chatelier also dwells on the fact that comparative analyses of the iron produced before and after the introduction of dried air are not given—naturally a feature of some moment. By calculating the coke consumed by the water vapour of the blast, the conclusion is reached that the amount of this vapour eliminated by refrigeration can only effect a possible economy of 3 per cent. and not 20 per cent. as stated. The real value of dessicated air is to be found in the lower sulphur content of the product. With hydrogen and water vapour present in the blast, the absorption of sulphur by the lime cannot be complete. One possible economy of the process, then, will lie in the fact that for a given sulphur content the blast furnace may be worked at a lower temperature with dessicated than with undried air. In conclusion Professor Le Chatelier suggests directions in which laboratory experiments may be conducted, the more important practical tests demanding costly outlay. Acting on Professor Le Chatelier's sug-

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*1. C. E. Heurteau. Revue de Metallurgie, Vol. I No. 12.

2. H. Le Chatelier. Revue de Metallurgie, Vol. I. No. 12.

3. O. Boudouard. Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences. Vol. CXL. No. 1.

4. B. Osann. Stahl und Eisen. Vol. XXV. No. 2.

5. Conrad Nix. Stahl und Eisen. Vol. XXV. No. 3.

gestion, Dr. Boudouard* has conducted certain experiments which are given in the *Comptes Rendus* of January 2nd. These experiments had for their object a study of the influence of water vapour on the phenomenon of the reduction of oxides of iron. The results clearly show that at low temperatures reducing gases are more energetic when in a dry than in a humid state, but at temperatures of about 1,000 deg. C. the difference is practically imperceptible. This feature is illustrated in the following figures :—

Temperature. Degrees Centigrade.	Percentage loss of Fe_2O_3 by weight.	
	Dry. $CO+CO_2$.	Moist. $CO+CO_2$.
400	0·87	0.45
550	4·3	3·8
800	4·0	2.65
925	5·6	4·4
1,050	6·3	6·9

In the foregoing, equal volumes of CO and CO^2 were employed on ferric oxide; in the following, carbonic oxide alone was employed on ferrous oxide :—

Temperature. Degrees Centigrade.	Percentage loss of FeO by weight.	
	Dry. CO.	Moist. CO.
850	15·3	11·0
1,050	21·5	21·5

The results in both cases are similar, showing that at temperatures in the vicinity of 1,000 deg. C. reduction is not retarded by the presence of water vapour. In the blast furnace, water vapour is in the neighbourhood of the tuyeres decomposed into hydrogen and oxygen, and there are no exact figures as to the ultimate action of this hydrogen, which in presence of carbonic acid can generate water vapour and carbon monoxide.

Turning to the German aspect, we note first an article in *Stahl und Eisen*, by Professor Osann, which practically amounts to strong condemnation of the Gayley process and a distrust of the figures given. The latter are based on trials of insufficient duration, and the advantages claimed as due to a uniform moisture content may be due to quite other causes. Professor Osann cites, amongst other variables, fluctuations due to varying moisture content of ore and coke, varying blast temperature, and changes in furnace conditions. Calculations of the thermal requirements of the furnace are given, which in themselves show the stated economy of coke due to dried air to be high. For, as the combustion of 1 lb. of carbon liberates about 1,380 calories with blast at 450 deg. C., then the proportion of carbon to iron will need to be 68.3 per cent., or, allowing 3·5 per cent. for absorption by the iron, a total of 71.8 per cent. A total carbon equivalent to 83.5 per cent. coke. The yearly average coke consumption of ten furnaces at the Edgar Thomson Works, Pittsburg, is 88 per cent., a figure in excess of the foregoing calculated total. Further data is given to show that the amount of coke consumed in eliminating moisture from undried blast, under the conditions cited by Mr. Gayley, is 3.13 per cent. of the iron in the charge. Therefore the possible lowering is to 80.4 per cent total coke consumption, which is higher than Gayley's figure of 77·7 per cent. Comparing these figures with the original coke charge at the Isabella Furnaces (some 96.6 per cent.), the saving would be actually 4 per cent. instead of the 20 per cent. quoted. From a comparison of the Isabella furnace, in which Gayley's experiments were made, with the Edgar Thomson furnaces, Osann concludes the former to have been in bad condition before the trials, a view practically coincident with that of Le Chatelier, though based on entirely different conclusions. Finally, after examining details of the blowing engines and refrigerating plants, if the former are inefficient, their employment on dried air may be an advantage. However, this is doubtful, for it would be cheaper to instal new engines than to add the necessary drying plant.

Later issues of *Stahl und Eisen* contain various letters on this absorbing topic. One, written from the view-point of refrigeration, is accompanied by diagrams showing atmospheric temperature and moisture variations, in monthly averages, for Pittsburg, Berlin, and Cologne. Another correspondent, C. Zix, challenges the fact of Gayley's economies being due entirely to the substitution of dried air. While he admits a possible slight saving of coke and a smaller expenditure of power by the blowing engines when operating on dried air, these factors cannot possibly account for the enormous saving of 20 per cent. effected in fuel consumption.

Foundry Practice.

Machine Moulding.—In last month's issue, Mr. F. Hermann's introductory article on machine moulding was noted, and it will be remembered that emphasis was laid on the right machine in the right place. Broadly, these machines may be divided into two classes—(1) in which the only mechanical operation is that of drawing the

pattern through a stripping plate, and (2) in which the mould is rammed by power. The two clases naturally converge, for (1) may be rammed by a lever, as in the familiar "squeezers," and stripping plates may be applied to power machines. In considering the economy of any type of machine, initial cost is by no means the first item; accessories demanded by each fresh set of patterns must always be included. Hence a power machine permitting of some elasticity may, notwithstanding high initial cost, prove more economical than a hand ramming machine demanding costly patterns and accessories. In the following we give various aspects of machine practice. However, before passing on to them it may be well to note two features of some moment.

(1) Ordinary plate moulding will, with changing patterns, readily compete with hand-rammed moulding machines. Plate moulding in conjunction with a hand press or "squeezer" is a proved economical method, and is elastic. When only few castings are required, patterns and plate are cheaply and efficiently constructed of wood, and such a plate will pay if only thirty sets of castings are required.

(2) Power machines, quite apart from mechanical accessories, demand good core-making facilities. A homely example will illustrate this feature. A machine operated by two men will turn out, say, 200 complete moulds per day; if each mould contains 20 castings, each of which require a core, then 4,000 cores are required a day. If these cores are at all intricate, then the capacity of that machine is determined entirely by the output of cores.

*Machine Moulding and Typical Moulding Machines.**—In his second article, Mr. F. Hermann describes various types of machines, the earlier descriptions applying to machines of the pattern-drawing type. As a type of hydraulic machine, we select the one shown in Fig. 1, from which the operation of the machine is apparent. Thus, one-half of a moulding box (*F*) is placed on the turning plate (*T*), and the other half (*F*1) on the trolley (*W*), the two halves being clamped to the turning plate by means of the clamps (*h*). The top half-box is filled with sand, the plunger (*K*) raised, and the whole pressed against the head (*G*). On returning, the plate is arrested by ferrules (*S*), is then turned over, and the process repeated on the half-box (*F*1), which is now uppermost.

* *Giesserei Zeitung*, Vol. I., No. 22.

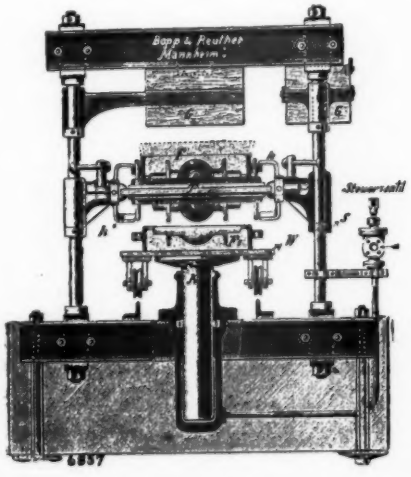


FIG. 1.—MACHINE MOULDING.

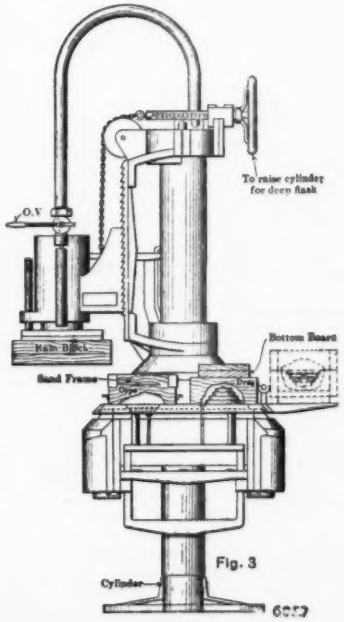
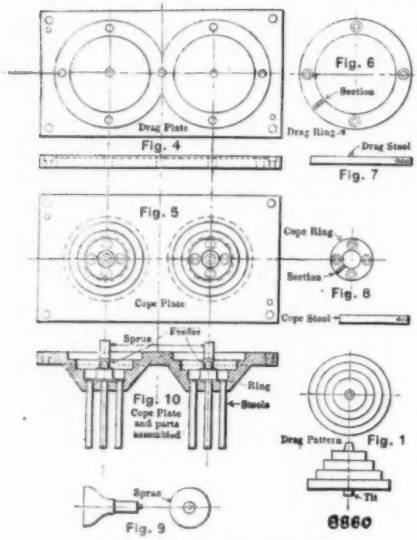


FIG. 2.—MACHINE MOULDING.



MOULDING MACHINE PRACTICE.

Moulding Machine Practice.—Mr. F. W. Hall describes, in a recent issue of *The Foundry*, a method of mounting patterns for moulding 5-in. cone pulleys, the only core involved being that required for the boss. Fig. 3 shows the moulding machine used, with the ramming block swung to one side and the moulding box broken away to show the pattern. The boxes used are 8 in. × 15 in., with 5 in. bottom parts and 3 in. top parts. Top and bottom halves are rammed at the same time, and the patterns drawn simultaneously by means of compressed air working in the lower cylinder. By use of a roll-over device, the mould is completed and put together, as shown on the right of Fig. 3, before removal from the machine. Details of pattern mounting are as follows:—Fig. 4 shows the drag pattern plate, the cope plate being shown in Figs. 5 and 10. A plan and sectional view of one of the stripping rings for the drag plate is shown in Fig. 6, and a stool post for the same in Fig. 7. A stripping plate for the cope pattern is shown in Fig. 8, and a stool below it (Fig. 9) shows a gate pin, and a sectional view of the cope plate with rings, stools, and weights assembled is shown in Fig. 10.

*Moulding Machines of To-day.**—Mr. H. M. Ramp, speaking from experience gained in managing a foundry operating sixty power and fifty stripping plate machines, discusses some of the essentials of machine moulding practice. Stripping plates represent the first aid rendered to hand moulding, and such devices, whilst occupying a strong position to-day, are in no sense machines. Power rammers, the next step in advance, have been developed in various directions and operated by friction, steam, compressed air and hydraulic power, the two last proving in practice the most serviceable sources of power. Stripping plates applied to a power-rammed machine make, in certain cases, a valuable combination; but whilst such a combination means costly patterns and accurate equipment, power ramming alone can be applied to any kind and form of pattern.

Stripping plate machines involve an expenditure of from one-quarter to one-half the value of the machine in fitting up each set of patterns, whilst for the same amount twenty to thirty sets of patterns can be mounted on follow boards suitable for power ramming. Hence, for general work with changing patterns, the initial cost of stripping plates and patterns is prohibitive, and in the end that machine will prove most economical which for the lowest first outlay will perform the ramming. Practically, these machines may be divided into two types, one ramming with a blow and the other by pressure. When working with small boxes, there is little to choose between the two; but for large boxes the pressure type is distinctly superior. Apart from other advantages, less power is required in a machine ramming by pressure than one working by a blow, especially when; as is usually the case, more than one blow is required.

*Moulding Machines and Their Uses.**—Mr. E. H. Mumford reviews the subject generally, giving, in conclusion, the following advice: "Regard whatever money you spend for the purchase of moulding machines as only the beginning of your investment. The cost of fitting the patterns to the machine comes after that; and you should not so order your machine as to be obliged to fit your patterns in only one way, and that perhaps the most expensive and most limited in application. Anyone can buy moulding machines, but few use them to best advantage."

Automatic Core Ovens Using Oil as Fuel.—Oil as a foundry fuel is possibly of more interest in the States than in this country. However, the following ingenious device for utilizing this fuel as a source of heat for core ovens is well worth attention. Mr. S. E. Barnes, in a paper read before the Philadelphia Foundrymen's Association,* described in detail the method employed. In order to heat the ovens through the night,

* *The Foundry*, January, 1905

* *The Foundry*, January, 1905.

* *The Iron Trades Review*, Vol. xxxviii., No. 2.

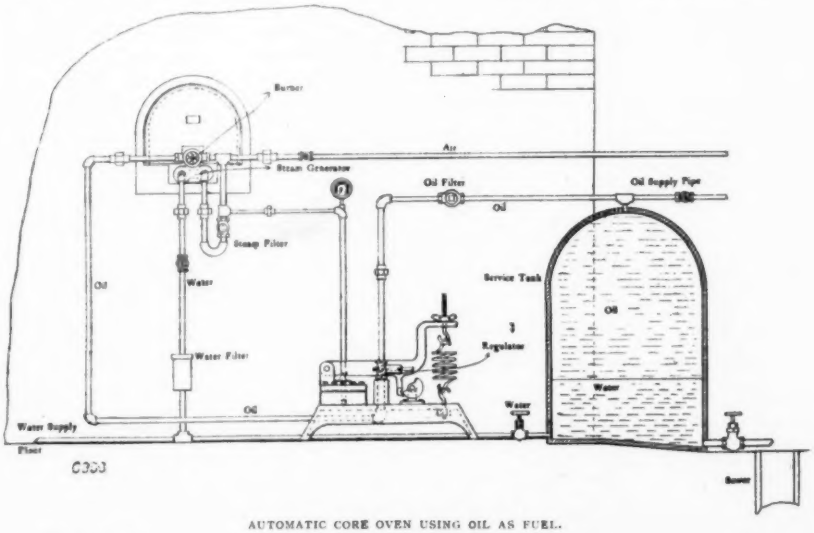
when compressed air was not available, steam was substituted for air, and the oven arranged to generate the necessary steam. The generator is a cast iron return pipe 3 ft. long, placed in the fire grate, with one end connected to the town water supply, and the other, or steam end, to the burner. The internal diameter of this return pipe is 7/8 in. When starting all cold, oil is first sprayed by means of compresed air, water admitted to the return pipe, and in a few minutes a steam-raising heat is reached. The heat is then shut off and the oil sprayed by steam only. In order to attain the necessary oil pressure, town water is led into the bottom of the oil tank, thus forcing the oil upwards. The flow of oil is regulated to the steam pressure, which opens or closes the oil valve automatically with a rise or fall in steam pressure. Should this pressure cease, the oil valve is closed and locked. A plan of the apparatus is appended, and this method of firing a core oven is stated to yield economical results and to be entirely free from accidents. In the subsequent discussion the author stated that two core ovens, about 9 ft. × 16 ft. × 12 ft., were in use, averaging 3 or 4 tons of sand per oven per night. The total oil consumption amounts to about 90 gallons per day, crude oil at 4 cents per gallon being employed.

The Small Convertor in Steel Foundries.—A recent issue of the *Iron Trade Review* contains a note on the development of the Tropenas process, from which the following is extracted:—"Castings of Tropenas steel have been used in some cases as substitutes for drop and hand forgings, and the process has been employed for machinery, agricultural, and railway castings, as well as for hammers, wrenches, anvils, gear wheels, crank shafts, and automobile parts. Ability to make steel of practically the same chemical composition as wrought iron has led to the use of the Tropenas process in the manufacture of castings for electrical purposes."

General Alloys.

*Mass Analysis of Muntz Metal.**—Mr. Rhodin, in a paper read before the Faraday Society, describes an electrolytic method of estimating copper in Muntz metal which meets the stringent requirements of a busy laboratory. Electro chemical properties of the alloy are also discussed. Muntz metal is used as a sheathing to protect ships' hulls from mollusca, and to be successful it should dissolve in sea water just to a sufficient extent as to render the surface poisonous, the best conditions being an equal dissolution of the copper and the zinc. These may be calculated approximately by supposing that the electrolytic dissolution rate is proportional to the heat of formation of the ultimate compounds (zinc and cuprous chlorides), and to the conductivities of the metals which dissolve. Assuming that both the chlorides of copper are formed, and tak-

* *Chemical News*, Vol. 91, No. 2,359.



AUTOMATIC CORE OVEN USING OIL AS FUEL.

ing the means of the results in the two cases, the best values are found to be 60.811 per cent. of copper and 39.189 per cent. of zinc—numbers which agree very closely with the results of practical experience.

Recent Tests of Alloys.—Mr. H. Souther discusses† variations in the physical properties of alloys, showing that in many cases chemical analysis will not explain the dissimilarities often found. Explanation must be sought in other directions, as, for instance, in the presence of gases, oxides, and dross, and in variations of casting temperature. These features have been fully dealt with in our columns,‡ but we turn with interest to some results obtained from manganese bronze. Thus, the first one described yielded the following mechanical properties :—

Elastic limit. lbs. per sq. in.	Max. stress. lbs. per sq. in.	Elongation per cent. on 2 ins.	Reduction of area per cent.
12,000	19,400	10	None.

The chemical analysis of this bronze was as follows :—Copper, 72.99 per cent ; iron, 1.50 per cent. ; zinc, 24.20 per cent. ; phosphorus, 0.01 per cent. ; and manganese, 1.30 per cent. As Mr. Souther tritely adds :—There was plenty of manganese in the finished alloy, but that did not seem to bring the required result. In direct contrast to this is a manganese bronze of another make, showing a wonderfully strong and tough alloy. As very often happens, however, no manganese appears in the finished product, and the analysis gives no evidence of any having been used. The buyer must take that on faith. Something was used, however, and, according to the notion of the writer, it was the brains of the manufacturer as much as the composition." The following are the mechanical results obtained from this bronze :—

Elastic limit. lbs. per sq. in	Max. stress. lbs. per sq. in.	Elongation per cent. on 2 ins.	Reduction of area per cent.
20,950	70,150	40	43

Its chemical analysis was as follows :—Copper, 59.9 per cent. ; tin, 1.1 per cent ;. iron, 1.48 per cent. ; phosphorus, trace ; manganese, none ; and zinc, 37.5. It is only just to add that the particular condition of this alloy is not stated.

*Physical Characteristics of Certain Bronze for Steam Uses.**—According to Mr. Kneass, the essential characteristics of a good steam metal are : homogenity, solidity, tensile strength, rigidity, facility for machining, fluidity in casting, and non-corrosiveness—requirements which are met by the various mixtures in use with varying degrees of excellence. The proper mixture for any desired purpose must therefore be a compromise with a fixed tendency toward homogenity and density. The author emphasizes the importance of the two latter properties by quoting service conditions. Thus, in the case of non-homogenity, the more soluble or softer portions of the alloy are more readily attacked by acid liquors or worn away by attrition. Whatever the source of wear, the harder portions are left in relief, and if the casting be a valve seat or face, contact is destroyed, with an inevitable leakage resulting. Finally, the author emphasizes careful attention to detail and conscientious treatment of steam metals in the foundry, but does not definitely indicate the extent or direction of this attention to detail.

† *The Metal Industry*, Vol. III., No. 1.

‡ *Fielden's Magazine*, Nov. and Dec. issues, 1904.

* *Journal of the Franklin Institute*, January, 1905.

A Destructor Installation at Zurich.

An interesting refuse destructor installation has recently been carried out at Zurich by the Horsfall Destructor Co., Ltd. The destructor comprises 12 cells, in which 120 tons of refuse can be burnt daily, just as it is collected by the dust-carts, without any addition of fuel. The carts are unloaded by means of an electric crane. An electrically-driven fan draws in the hot air over the furnace doors and sends it back through the blast flues to the sides of each furnace.

The air thus heated passes through the grate bars and is forced into the main flue, which is kept in an incandescent condition by the gases coming from the furnaces. The mixed gases then pass to the boiler house, where two boilers are at present installed, each having a heating surface of 170 square metres.

The steam, at a pressure of 8 kilos per sq. cm., is passed through a superheater to a 165 h.p. Brown-Boveri Parsons turbine, which drives a three-phase 150 kw. alternator. Part of the current thus generated is utilised for driving the auxiliary plant, the surplus going, after transformation, to the Municipal Distributing System. The clinker, which represents from 30 to 40 per cent. of the refuse, can also be utilised, being well adapted for the manufacture of special bricks.

Book Reviews.

ENGINEER'S VALUING ASSISTANT: Being a Practical Treatise on the Valuation of Collieries and Other Mines, with Rules, Formulæ, and Exampes; also a Set of Valuation Tables and Tables of Value. By H. D. HOSKOLD, Civil and Mining Engineer, Chief of the Argentine Government National Offices of Mines and Geology. Second Edition. Longmans, Green & Co., 1905.

Pubished in 1877, the first edition of this work was soon exhausted, but the onerous duties of his office in connexion with mining department of the Argentine Republic prevented the author from undertaking the preparation of a second edition until quite recently. We may remark at the outset that the title of the volume is somewhat calculated to raise delusive hopes in the minds of engineers generally. If entitled the "Miner's Valuing Assistant," there would be no reason for criticism. In the original preface, Mr. Hoskold expressed his surprise that the literature of mine valuation should have been entirely neglected—a circumstance, however, which may be attributed to the comparatively small number of those engaged in this department of work. Still, a little reflection will show the truth of the statement that "commercial prosperity seems to depend more or less upon its relations to honest and successful mining adventure." The purport of the treatise is indicated in general terms by the following extract:—"Immense sums of money are frequently spent in the purchase of mineral properties, and it is a common occurrence that much more is paid in order to secure them than they are really worth; and cases coming within experience are by no means few where the estimated value has exceeded the true value by 40 or 50 per cent., due in many cases to the employment of an erroneous year's purchase.

Read in the light of revelations made from time to time in the daily press, the first part of this quotation has a flavour of delicate irony which is not less delightful because it is evidently unintended. The work is of decidedly serious character, and contains matter of the greatest interest to the professional valuer, discussing the principles upon which his practice should be based and treating problems of somewhat unusual nature arising in the practical application of those principles. The tables, occupying more than 157 pages, are divided into two categories: one set comprising Valuation Tables dealing with the principle of allowing interest to a purchaser of any annuity, benefit, or income, derived or to be derived from mines or otherwise, at one rate of interest, and redeeming the capital invested at another practical rate of interest; and the other consisting of Tables of Value showing the discrepancies existing in the ordinary tables of present values and the errors created by them. The method of valuation advocated by Mr. Hoskold appears to be mathematically correct, and the manner in which he has supplied it affords ample testimony to the immense amount of labour bestowed upon the preparation of this volume.

THE FAN: Including the Theory and Practice of Centrifugal and Axial Fans. By CHARLES H. INNES, M.A. (Cantab.) Lecturer on Engineering at Rutherford College, Newcastle-upon-Tyne. The Technical Publishing Co., Ltd., Manchester, 1904.

Any treatise which has for its object the further elucidation of the principles governing the design of fans must be welcome to engineers concerned in the manufacture and application of these useful appliances. In the present work, a theory of the fan is propounded, which, by reason of its novelty, may meet with some criticism. But it is distinctly worthy of consideration, being, in effect, based upon the theory of the centrifugal pump. After dealing at some length with experimental records, the author enters upon an instructive comparison between theory and experiment, which appears to indicate that his theory is fairly in agreement with the results of the most trustworthy tests. In Chapter XV. he propounds a theory of the air propeller, and although this is the most simple type of fan, its scientific design involves the atempt to solve very complicated problems. The theory enunciated by Mr. Innes is by no means complete, a circumstance chiefly due to the lack of experimental data. The volume is concluded by descriptions of propeller ventilating fans and an account of the Rateau screw fan. It is a book well worth reading.

THE CENTRIFUGAL PUMP, TURBINES, AND WATER MOTORS: Including the Theory and Practice of Hydraulics. (Specially adapted for engineers.) By CHARLES H. INNES, M.A., Lecturer on Engineering at Rutherford College, Newcastle-upon-Tyne. Fourth and Enlarged Edition. Price, 4s. 6d. net. The Technical Publishing Co., Ltd., Manchester, 1904.

This work comprises a well-reasoned explanation of the theory of hydraulic engines, turbines, and centrifugal pumps. The present edition includes a new chapter on High Pressure Fans and Pumps, and descriptions

of steam turbines from particulars furnished by Mr. C. A. Parsons.

In addition to the chapters devoted to the types of machinery indicated on the title page, the author includes two others dealing with the construction and theory of fans. Several of the illustrations and much of the literary matter in this part of the volume are identical with those to be found in the separate treatise on "The Fan" by the same author. Duplication of material in this manner is scarcely necessary, especially in the case of two works published within three months of each other. Apart from this criticism there is little fault to be found. The theoretical discussion is clear, the descriptive accounts of various types of machines are good, and both classes of reading are illustrated by numerous diagrams and drawings. We are sorry to see, however, that many perspective views are included, which, being reproductions from commercial catalogues, represent a class of illustration quite unsuitable for a scientific textbook. Taken as a whole, the work is one possessing considerable interest and value for engineering students and others desiring to qualify themselves for the design of machinery of the types considered.

THE CONSTRUCTION OF CRANES AND OTHER LIFTING MACHINERY. By EDWARD C. R. MARKS, Associate Member of the Institution of Civil Engineers, Member of the Institution of Mechanical Engineers, Fellow of the Chartered Institute of Patent Agents. Third Edition, Revised and Enlarged. Price, 3s. 6d., net. The Technical Publishing Co., Ltd., Manchester, 1904.

In its original form, this work was a series of notes upon standard types of lifting machinery, such as pulley blocks, crabs, cranes, and lifting jacks; and although not sufficiently technical to be of any practical help to the designer, the details collected might fairly be considered as likely to interest those desiring merely general information on the subject. To these notes were appended, in the second edition, abstracts collated from patent specifications—a bookmaking device which can scarcely be commended. In addition to the foregoing, this issue contains a series of seven new chapters describing actual examples of modern practice by leading manufacturers of lifting machinery. We do not know why these chapters were added. The illustrations, being merely pictorial, teach nothing, and the letterpress tells little more than an ordinary trade catalogue.

MACHINES AND TOOLS EMPLOYED IN THE WORKING OF SHEET METALS. By R. B. HODGSON, A.M.I.Mech.E., Author of "Emery Grinding Machinery." The Technical Publishing Co., Ltd., Manchester, 1903.

Comparatively little has been written upon the various presses and other tools employed for the working of sheet metals, the manufacture of these constituting a branch of engineering which is quite distinct from engine fitting and general machine construction. For this reason it is difficult for an engineer without previous experience to undertake the work of a press tool maker, the difficulty in question being largely due to the many technical details connected with the process through which metal articles have to pass before reaching the final stage. The general subject discussed by the author applies to several industries, and the art of metal working covers a large number of different processes. In his work, the author has taken each section separately, but where necessary for the proper explanation of any point under consideration reference is made to other chapters of the book in which such matters have been entered into more fully. The subject matter originally appeared at intervals in the columns of the *Practical Engineer*, and as now collected in book form, we feel sure that it will be found of much practical service to engineers, technical students, and mechanics.

EXPERIMENTELLE UNTERSUCHUNGEN VON GASEN. Von Dr. Morris W. Travers, Professor am University College in Bristol, Mitglied der Royal Society und des University College in London. Miteinem Vorwort von Sir William Ramsay, K.C.B. Deutsch von Dr. Gadeusz Estreicher, Privatdozent an der K. K. Jagellonishen Universität in Krakau. Nach der Englischen Auflage vom Verfasser unter Mitwirkung des Ubersetzers neu bearbeitet und erweitert. 1905. [Braunschweig: Druck und Verlag von Friedrich Vieweg und Sohn. Mk. 9.]

In name this volume is a German translation of an English work, and on that account English students will probably prefer to go to the original work in their own language for instruction on the subject with which it deals. But in reality this is much more than a mere translation of the English text of Dr. Morris Travers' work on "The Experimental Study of Gases." That work appeared in 1902, and since its appearance many investigations have been carried out, producing valuable results which have added very considerably to our knowledge of the behaviour of gases under different conditions of temperature and pressure. We need only mention the work done in these last two years on the liquefaction of gases and the gradual progress that has been made in getting nearer and nearer to the absolute zero

of temperature. Work of this kind not only adds new facts to our knowledge, but gives rise to modifications of old facts, so that a text-book of 1902 may require revision at the end of 1904. That has been done in the present case, for in preparing the work for the German public the author and his collaborator and translator, Dr. Estreicher, have thoroughly revised the original text so as to incorporate all the new data obtained in the intervening years, and Dr. Estreicher has added some new matter on the latent heat of evaporation of liquid gases. It follows, therefore, that, for the present at least, the English reader who desires to consult a text-book giving the most recent experimental results and methods of investigation must turn to the German edition of Dr. Travers' work.

The details of the volume need not here be considered, as the scheme of the original work is already well known, and as the author is acknowledged to be a leading investigator in this branch of science. We would only express the hope that a new English edition of the original work may soon be called for, so that English physicists and chemists may have in a more convenient form all the information now put before the German public. Until then, students who can read German would do well to consult the volume now under notice, which is excellently printed and illustrated, and gives evidence of careful preparation.

CALCAREOUS CEMENTS: Their Nature, Manufacture, and Uses, with Some Observations on Cement Testing. By GILBERT R. REDGRAVE, Assoc.Inst.C.E., and CHARLES SPACKMAN, F.C.S. Charles Griffin & Co., London. 15s. net.

Perhaps in no branch of industry have so many important developments taken place during the past few years as in the manufacture of Portland cement, all incident to the introduction of the rotary kiln and tube mill; hence the necessity of a complete revision of this well-known and appreciated handbook. In the new edition, entire chapters have been re-written, embodying descriptions of the most recent processes adopted in this country, the United States, and on the Continent, where the manufacture of cement has developed to an amazing extent. The chemistry of the subject has also received full treatment, and the chapter dealing with the analysis of cement mixtures will be found exceedingly valuable. It is, perhaps, somewhat unfortunate that the volume and the standard specification of the Engineering Standards Committee should have been issued almost simultaneously, as reference to the latter in the book itself was thereby rendered impossible. The standard specification, however, is readily procurable in separate form. The book, which consists of 310 pages, is admirably printed and illustrated, and, coming at a moment when so much interest is being displayed in cement manufacture, it should have a large and immediate sale, particularly as everyone having the slightest concern with the use of cement will find it a most useful work of reference.

VALVES AND VALVE GEARING. By CHARLES HURST. Fourth Edition. Charles Griffin and Co., Ltd., London. Price, 10s. 6d.

The new edition of this excellent work comes to us in a considerably enlarged form, due to a complete revision having been made and the scope of the book considerably extended. To the portion dealing with the steam engine particulars of Corliss dashpot springs, a table of sizes and catches, and the proportions and designs of various details have been included. New gears also have been dealt with, as, for example, the Robinson shaft governor, Walchaert's gear, valve-end rods, Murgrave's latest trip gear, Borsig and Tosi gears, etc., and technical points in manufacture inserted where considered by the author necessary. The utility of the work, however, has been considerably increased by the addition of three new sections devoted respectively to gas engine valves, air compressor valves, and pump valves, so that it now forms a very comprehensive treatise on the subject of valve gearing generally.

The printing and illustrations, which latter have in many cases been greatly improved, leave nothing to be desired, and all who desire to bring their knowledge of this subject up to date cannot do better than by obtaining this excellent work.

MACHINE TOOLS AND WORKSHOP PRACTICE FOR ENGINEERING STUDENTS AND APPRENTICES. By ALFRED PARR, University College, Nottingham. With an Introduction by WILLIAM ROBINSON, M.E., M.Inst.C.E. Longmans, Green & Co., London. 10s. 6d. net.

This work has been prepared as a result of the increasing demand for instruction in the working of machine tools and as an aid to workshop practice generally; in fact, the book is an outcome of a course of instruction on these subjects at University College, Nottingham. The method of doing work, consequent upon the introduction and employment of automatic machinery, the extensive use of the grinder, and the working to limit gauges, etc., is very different to that which was in operation several years ago. The book deals in an effective manner with these newer methods, and its careful use will enable students to grasp their importance and to understand the action of the machine he uses. For example, Chapter I. is given up to the sub-

ject of Measurement, which is treated and illustrated in detail, by reason of the fact that nowadays it is of the first importance, owing to the use of interchangeable parts and the necessity of producing work economically within a definite limit of accuracy. Other chapters deserving of special mention (which have been prepared with the same amount of detail) are those on Turret Lathes, Grinding, and Milling, as has that on "Methods of Working," contributed specially by Mr. Claude W. Hill, A.M.Inst.C.E. The book, which comprises no less than 444 pages, is admirably printed and profusely illustrated, and is without question the most clear and valuable exposition of the subject that we have seen. It is essentially a practical work, and should take its place as a standard work in technical schools and colleges.

TOOLS FOR ENGINEERS AND WOODWORKERS, INCLUDING MODERN INSTRUMENTS OF MEASUREMENT. By JOSEPH HORNER, A.M.I.Mech.E. Crosby, Lockwood & Son, London. 9s. net.

This volume has been written from the practical standpoint, and is intended more especially for those who have occasion to use the tools or make them; that is to say, for the student of mechanical engineering, or the pattern maker, moulder, turner, and fitter, and finally the tool maker. The scope of the contents may be gathered from the sections into which the book is divided, viz., The Chisel Group, Scraping Tools, Tools Related to Both Chisels and Scrapers, Percussive and Moulding Tools, Tools for Measurement and Test; and it is not too much to say that the author has handled the subjects with a facility begotten of mastery. The book is certainly the most comprehensive of any we know devoted solely to the subject of tools, which will be appreciated when it is stated that it runs into 340 pages.

MECHANISM. By S. DUNKERLEY, M.Sc., A.M.Inst.C.E. Longmans, Green & Co., London. 9s. net.

As denoted by its title, this volume is given up to the treatment of pure mechanism, written to meet the requirements of University and Technical College students. It makes no pretence of dealing with the subject philosophically, for, as the author points out, there are the works of Willis, Rankine, and Reuleaux for that.

It is essentially a practical treatise, and the book should be welcomed as a useful addition to engineering literature.

A preliminary chapter deals with various machine tools, and of mechanisms required for special purposes, and great care has evidently been taken in the selection of illustrations of general interest.

The remaining chapters include a full discussion of straight line motions, indicator mechanisms, quick return motions, couplings, velocity diagrams, approximate solutions to link motions and radial valve gears, acceleration diagrams, toothed wheels, cams, and machines for cutting teeth. There is a very complete index and a number of numerical examples, with answers, which should prove useful in testing the reader's grip of the subject as he proceeds.

A COMPLETE CLASS BOOK OF NAVAL ARCHITECTURE: PRACTICAL, LAYING OFF, THEORETICAL. By W. J. LOVETT, Belfast Municipal Technical Institute. Longmans, Green & Co., London. 7s. 6d. net.

This excellent little manual has been written with the idea of supplying at a reasonable price a book that would be within the means of and appreciated by a great many shipwrights, platers, draughtsmen, and students to whom the standard works are prohibitive in cost.

The result is that a clear and interesting, if somewhat elementary exposition of the problems which have to be considered in building a ship has been furnished by the author, but which will nevertheless provide a profitable preliminary course in the subject. The needs of students working for the examinations of the Board of Education have been specially catered for, as this syllabus has been used as the basis for the work.

The book, which is well printed and illustrated, consists of 283 pages, well indexed, and contains a useful series of ruled pages at the end for notes and references—an example which might well be copied in students' books generally.

POCKET BOOK OF MARINE ENGINEERING RULES AND TABLES. By A. E. SEATON, M.Inst.C.E., M.I.N.A., and M. ROUNTHWAITE, M.I.Mech.E., M.I.N.A. Charles Griffin & Co., Ltd., London. 8s. 6d.

In the eighth edition of this popular and useful handbook a very complete revision has been made, so that it is now quite up to date. New formulæ and tables relating to the speed of ships have been added, which will be found very useful in determining more accurately and with greater confidence the horsepower necessary for the speed of ships of all kinds. A number of new tables have been added and old ones extended, and the recent additions and alterations to the Board of Trade and Lloyd's Registry rules, etc., have been included. All engaged in marine engineering will find this handy volume a desideratum.

CATALOGUES AND TRADE PUBLICATIONS.

Pneumatic Tools.

The Consolidated Pneumatic Tool Co., Ltd., 9, Bridge Street, Westminster, S.W.—Special circular No. 9, of Little Giant and Whitelaw pneumatic drills, fitted with patent rock, iron ore and coal boring attachment; Boyer hammer with rotating device; various improved rock drills and stone dressing machines.

Gearing.

Johnson & Phillips, 14, Union Court, Old Broad Street, E.C.—Illustrated booklet descriptive of the "Newman" variable speed gear suitable for motor cars, electric driving, machine tools, etc. The speed ratios are not fixed in this mechanism but are perfectly variable from zero to maximum.

Water Softening.

Kinnicott Water Softener Co., 29, Great St. Helens, E.C.—Pamphlet descriptive of a "tipping box type" of water softener, which has been designed for the treatment of a limited quantity of water required for small size plants

Steam Raising Plant.

Ed. Bennis & Co., Ltd., Bolton.—Well illustrated and printed booklet, giving full details of construction, application and tests of the Bennis patent stoker and furnace.

Babcock & Wilcox, Ltd., 30, Farringdon Street, E.C.—"Steam." Fifth edition of this useful publication, which has been revised and enlarged to include fresh information on refuse destructors, superheating, boiler installations in large power houses, etc.

Electrical Instruments.

Geipel & Lange, 72A, St. Thomas Street, E.C.—Circular of the "Vulcan" watt-hour meters of both switchboard and consumer's types.

Cranes.

Royce, Ltd., Hulme, Manchester.—Third edition of this company's handsome pamphlet illustrating and describing a variety of types of electrically-driven cranes and other appliances designed and constructed by them.

Non-Conducting Coverings.

The United Asbestos Co., Ltd., Dock House, Billiter Street, E.C.—Revised and enlarged edition of a pamphlet, the illustrations and text of which will be found valuable to all interested in coverings for the prevention of radiation and condition of heat. Also a Digest of Report on Tests of Locomotive Boiler Coverings, issued by the Western Railway Club, Chicago, and re-published by the United Asbestos Co.

Lawson's Non-Conducting Composition, Ltd., Victoria Road, St. Phillips', Bristol.—Circular descriptive of Lawson's Asbestos Mattresses for covering boilers, economisers, etc. The feature of these coverings consists in the improved method of fastening which is effected by two laps, one at the side of the mattress and the other by a pleat in the cloth. Both are provided with riveted brass eyelets, and are so arranged as to meet about 2 in. from the point where the mattress butts, a good joint being thus obtained.

Electric Wiring Specialities.

The Simplex Steel Conduit Co., Norfolk Street Strand, W.C.—Price list for 1905, containing reduced prices of all Simplex conduits, together with a leaflet showing important percentage reductions in the price of material. Also copy of the company's Wiring Handbook, dealing very fully with the erection and wiring of the Simplex conduit system.

Valves.

W. H. Bailey & Co., Ltd., Salford, Manchester.—List No. 304 of "full-gate" parallel slide valves for high-pressure and superheated steam; sluice valves for water, gas, etc., automatic exhaust valves, etc.

Gaukroger, Sykes & Roberts, Ltd., Halifax.—Price List of steam and radiator valves, unions, elbows, and cocks.

Packings.

J. Bennett von der Hevde, 6, Brown Street, Manchester.—Illustrated pamphlet of Duval's patent metallic packing.

Oil Engines.

R. Hornsby & Sons, Ltd., Grantham.—List H 702 of the Hornsby improved oil engine. Also a well-printed, finely-illustrated booklet dealing with the Hornsby upright water-tube boiler. The particular feature of this steam generator consists in the facility with which it can be cleaned, four to five hours sufficing this operation, including the time required for reducing and raising the steam pressure.

Electric Cables.

Johnson & Phillips, Old Charlton, Kent.—Pamphlet dealing with cables and junction boxes. Special attention may be drawn to the underground network disconnecting and fuse-boxes with bell covers. These are self-contained and are easy to get at, there being no bolts and nut on the covers.

HEATING APPARATUS.

Hartley & Sugden, Ltd., Atlas Works, Halifax.—1905 edition of this company's catalogue of boilers and apparatus for low-pressure, hot water or steam heating. The list contains some data and notes which will be found useful to heating engineers.

MISCELLANEOUS.

The Engineering Diary and Pocket Magazine, 17, Bouverie Street, London, E.C.—The February number of this useful publication. It is a combined pocket-book and diary issued month by month at 6d., or for an annual subscription of 6s. 6d., post free. The pocket-book portion contains many useful tables and curves which the publishers are extending by a prize award for the best original data of general interest to engineers. The diary portion is on fine squared paper, one page being allocated to each day.

J. Parkinson & Son, Shipley.—List E1 of Vices.

CALENDERS.

Consolidated Pneumatic Tool Co., Ltd.—Handsome tear-off calender, with beautifully embossed half-tones of some of the company's leading specialities.

Coal-Conveying Installation at Sydney Gas Works.

AN important installation of a duplicate coal-handling plant at the Australian Gas Light Company's Works, Sydney, has just been carried out by Messrs. Graham, Morton & Co., Ltd., Leeds. The plant possesses several features of interest.

The contract included the supply and delivery of two receiving hoppers, two standard four-roll crushers, two 12 in. lattice-braced elevators, two 16 in. rubber-belt conveyors, two coal bunkers (with the necessary structure for supporting the same), two 17½ b.h.p. steam engines with the requisite shafting and gearing for driving the entire plant.

The four-roll crushers are built up of steel side and end plates, firmly bolted together, and provided with shafts, cast steel tooth rollers, guide plates, and the requisite gearing, etc., for working them. The structure on which they are supported consists of 8 in. by 3½ in. channels, built into the wall at one end, and supported by 8 in. by 6 in. cross joists at the other.

The shoots provided for the elevator boots are constructed of $\frac{3}{8}$ in. plate throughout, the side plates being flanged and riveted to the ends, the result being in each case a very substantial piece of work.

The two elevators are of the 12 in. standard lattice-braced type, 58 ft. between centres, and each consisting of a suitable cast-iron boot, in which is arranged the adjusting gear for taking up and adjusting the length of chain. A cased-in framework of angle iron runners, and angle iron stanchions, lattice-braced throughout, completes the design.

The driving and trailing end fittings are constituted of cast-iron sprocket wheels, provided with the necessary pedestals and loose collars, and also with adjusting screws for taking up and adjusting the length of chain.

One strand of chain is supplied to each elevator, tightly stretched over the end drums, thereby forming a continuous travelling chain, to which, at intervals of 18 in. pitch, are attached the buckets and skidder bars. One $\frac{5}{16}$ in. plate wrought-iron breeches shoot is provided to each elevator, and arranged with flap door, spindle and lever mechanism, for diverting the coal, either on to the belt conveyor or into the coal bunker, as may be desirable.

The coal bunkers are of wrought iron, and built up of ¼ in. plate throughout, each being fitted with slide door and operates in the easiest possible manner.

Each of the elevator pits is covered by ⅜ in. wrought iron chequer plates suitably supported. Access to the pits is obtained by ladders of some 13 ft. long. The belt conveyor is 30 ft. 6 ins. between centres. It consists of two end drums, made up of cast iron sides, with wrought iron body plates, each drum mounted on its shaft, and the trailing shaft working with adjustable ends, and fitted with adjusting screws for tightening the belt. The belt itself is of the well-known Graham Rubber Type, and is supported on the carrying side by Graham's Patent Inclined Idler Rollers, made of cold drawn steel tubing, and fitted with hollow self-lubricating spindles throughout, adjusting blocks, &c. These rollers are pitched about 5 ft. apart. On the bottom or return side the belt is supported by means of flat rollers, pitched 10 ft. apart, mounted on 7 in. × 2 in. pitch pine battens, bolted to the structure. The belt drums, one central and two side drums, are built up of cast iron centres with wrought iron tubes, mounted on tube spindles, and provided with screw lubricators. They are placed at an angle of about 30 degrees.

Coming now to the gearing; a short shaft is coupled on to the end of the engine shaft, from which, by means of a belt drive, a four-roll crusher is actuated. From the end of the same shaft, a second, connected by gearing, is carried up the side of the elevator, and by means of bevel gear drives the elevator. The belt conveyor is driven by means of a chain from the elevator head shaft.